

Faure New Water Scheme



CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD



Independent Advisory Panel **Report: Findings and Recommendations** 2022 | 2023



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The IAP wishes to express their deep gratitude towards the WRC, especially Dr Nonhlanhla Kalebaila and Dr Buyisile Kholisa, the CoCT officials responsible for the Faure NWS, in particular Mr Mike Killick, Ms Kaashifa Aziz, Ms Nqobile Simelane, Dr Swastika Surujal-Naicker, Mr Hennie Kotze, and everyone else who took time to share their information and experiences, as well as the project team from Zutari, in particular Mr Brendon Theunissen, Daniel Petrie, Louis Koen, and many others without whom the IAP would have been unable to conduct their work.

Executive Summary

The City of Cape Town (CoCT or 'the City') became known around the world as the city that, after enduring a severe drought (the worst on record) between 2015 and 2018, narrowly avoided 'Day Zero' (running out of water supply for domestic use) through the implementation of significant water conservation measures, including restrictions on its residents. To prevent having to face a similar challenge in future, the City developed a Water Strategy, "[Our Shared Water Future](#)", which was published for public comment in March 2019, and finalised in 2020. This Strategy provides a roadmap towards a water resilient future.

Considering the decision-making criteria as captured in their Water Strategy, the CoCT identified a number of options to augment its current raw water supply sources, including from utilisable groundwater resources; maintenance of infrastructure to reduce leaks and losses; desalination of sea water; and removal of alien vegetation. These options have already been implemented throughout the City since 2018. One option that would augment raw water supplies, which has been identified but not yet implemented, relates to the further treatment of final treated effluent from a wastewater treatment plant (WWTW) at an Advanced Water Treatment Plant (AWTP) to produce 'reclaimed water' (sometimes also referred to as Purified Recycled Water (PRW)) to be treated at an existing Water Treatment Plant (WTP) to be suitable for human consumption.

Schemes to augment raw water supplies through the reclamation of treated effluent have been successfully implemented in many cities across the world, at locations as depicted in Figure 2 on page 2, including in southern Africa. The CoCT partnered with the Water Research Commission (WRC) for the coordination and provision of research, development, and innovation to support the investigation and implementation of such a water reclamation scheme in the CoCT. This scheme entails the further treatment of final treated effluent from the Zandvliet WWTW at a new AWTP (referred to as the Faure New Water Scheme (NWS)), to produce reclaimed water that can be blended with source water from the City's water supply dams, prior to treatment at the existing Faure WTP, from where drinking water is distributed to the water supply system of the CoCT. The implementation of this reclamation scheme could potentially provide the CoCT with an additional 70 – 100 Mℓ of water per day to augment its water supply.

The WRC established an Independent Advisory Panel (IAP) to provide expert scientific, technical, engineering, project implementation, and related best practice advice regarding the development of the Faure NWS for the CoCT. The members and expertise of the IAP is summarised in **Annexure "A"**. The IAP was established in July 2022, and its activities to date entailed the review of project design and other project-related documents; drafting of comments on these documents; site visits to the Faure WTP, the Zandvliet WWTW, and the City's laboratories; and deliberating its findings on these aspects in a number of meetings and workshops with representatives of the CoCT, and their project engineers and specialists from Zutari.

The information (documents and presentations) related to the Faure NWS that was made available to the IAP up to 27 April 2024 is summarised in **Annexure "B"**. It is not the purpose of this Report to summarise all the information reviewed, and it should also not be regarded as an engineering report, but rather as a report containing the expert opinions and recommendations of the members of the IAP as peer reviewers of the project.

The **purpose** of this Report is to summarise aspects that the IAP considers as key and critical in respect of the appropriateness of the design and the successful implementation of the Faure NWS, and relate to the following:

- Water and Sanitation Safety Planning aspects, including the protection of the quality of source water entering the Zandvliet WWTW from users in its upstream catchment;

- The proposed design of the treatment processes in the AWTP at the Faure NWS, and the treatment targets for the reclaimed water to be produced by the Faure NWS, especially with regard to effective treatment (removal/inactivation) of chemicals and pathogens (viruses, bacteria, and protozoan parasites), as monitored at selected Critical Control Points (CCPs) and Control Operating Points (COPs) to ensure that treatment targets that will protect public health are met on an ongoing basis;
- Regulatory aspects associated with the implementation and operation of the Faure NWS;
- Aspects relating to institutional arrangements for different line-functions within the City, especially for line functions such as procurement and supply chain, to ensure the successful implementation of the Faure NWS; and
- Aspects to be addressed in ensuring public awareness and education with regard to the suitability of the reclaimed water produced by the Faure NWS for human use and consumption and in engaging the public in a manner that facilitates dialogue and interaction, with responsiveness by the City to comments received on or concerns raised regarding the project.

Each of these aspects are discussed in this Report, together with relevant key and critical findings and recommendations of the IAP, which are based on the outcome of its work undertaken during 2022 and 2023.

It is trusted that the findings and recommendations of the IAP as contained in this Report will be taken into consideration to assist in the successful implementation and sustainable future operation of the Faure NWS.

Submitted on behalf of the IAP



Independent Advisory Panel: Faure NWS

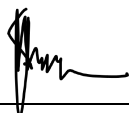
Mr Ian Law

Chair

12 November 2024

Report Receipt and Sign-off

The contents of this Report are noted on behalf of the WRC and the CoCT:



For: Water Research Commission

Mr Jayant Bhagwan

Executive Manager: Water Use and Waste Management



Michael Killick

26/12/2024

For: City of Cape Town

Mr Mike Killick

Director: Bulk Services



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Glossary of Terms used in this Report

There are many different terms used in the water sector that relate to the reclamation or reuse of water for purposes of human consumption. The terms used in this Report should not be read as being prescriptive of which terms should be adopted by the CoCT or even by South Africa. A recommendation of this Report is that terminology used in relation to this project should be tested by the CoCT as part of its Communication Strategy. Therefore, the terminology used in this Report is aimed at ensuring uniformity, consistency, and understanding in relation to the following terms used in this document, some of which are illustrated in Figure 3 on page 3.

Terminology used in this Report related to Water Quality, Water Treatment, and Water Reclamation for Reuse	
Source water	Water in its natural state, including surface water (rivers and dams), and groundwater (also seawater in some areas). Source water can also be referred to as "raw water". As source water is affected by both natural chemical and biological processes and may or may not have been affected by human activities such as uncontrolled effluent discharges or controlled treated effluent discharges from for example a Wastewater Treatment Works (WWTW)), it is treated at a Water Treatment Plant (WTP) to meet standards showing it to be safe for human consumption.
Purification	Purification refers to the removal of physical, chemical, and microbial contaminants from water so that it is not harmful to humans when consumed, or to environmental systems when discharged.
Disinfection	Water disinfection refers to the removal, deactivation or destruction of pathogenic microorganisms, resulting in the termination of their growth and reproduction.
Pathogen	A pathogen is defined as an organism that can cause disease to its host, with the severity of the disease symptoms referred to as virulence. Pathogens are taxonomically widely diverse and comprise viruses, bacteria, as well as unicellular and multicellular eukaryotes (including protozoan parasites).
Wastewater Treatment	The process at a WWTW that removes physical, chemical and microbial contaminants from the wastewater, to produce a final treated effluent that can be reused for various purposes or returned to the water cycle. Once returned to the water cycle, the final treated effluent becomes part of the water cycle and subject to physical, chemical and biological influences in water bodies, from where it can be abstracted for various purposes, including treatment at a WTP.
Water reclamation and reclaimed water	Water reclamation is the process of converting municipal/sewage/industrial or any other wastewater into water that can be used to augment freshwater supplies for domestic purposes by a community. Reclaimed water can also be referred to as Purified Recycled Water (PRW).
Recycled water and reused water	When treated or untreated wastewater is used for the same purpose as the source water, it is considered recycled water. The use of treated or untreated wastewater for purposes other than domestic use is considered reused water.
Indirect Reuse of reclaimed water	Indirect reuse of reclaimed water refers to water reuse processes that incorporate an environmental buffer in the water cycle, such as a dam, groundwater aquifer or surface reservoir, and into which treated effluent from a WWTW is discharged where it comeslingles with the natural water before being abstracted for treatment at a WTP.
Direct Reuse of reclaimed water	Direct reuse of reclaimed water refers to the direct introduction of reclaimed water into a distribution system to facilitate domestic use by a community.
Blended Reuse of reclaimed water	The blended reuse of reclaimed water refers to the use of reclaimed water blended with source water prior to further treatment in a regular WTP prior to distribution to facilitate domestic use by a community.

Units of Measurement

ℓ	litre	μm	micrometre (micron)
mℓ	millilitre	cm	centimetre
kℓ	kilolitre	m	metre
Mℓ	megalitre (1 Mℓ = 1,000 kℓ)	m ²	square metre
mg/ℓ	milligram/litre (parts per million or ppm)	m ³	cubic metre (1 m ³ = 1 kℓ)
μg/ℓ	microgram/litre (parts per billion or ppb)	mS/m	milliSiemens/metre
J	Joules	mV	millivolt
kPa	kilopascal		

List of Abbreviations

Abbreviation	Description
AOC	Assimilable Organic Carbon
AOP	Advanced Oxidation Process
ASTM	American Society for Testing and Materials
AWTP	Advanced Water Treatment Plant
BAC	Biologically Activated Carbon
BDOC	Biodegradable Organic Carbon
BNR	Biological Nutrient Removal
CAS	Conventional Activated Sludge
CCP	Critical Control Point
CCR	Cumulative Risk Rating for Green Drop Assessment
CECs	Contaminants of Emerging Concern
CoCT	City of Cape Town
COD	Chemical Oxygen Demand
COP	Control Operating Point
CT	Contact Time
DBP	Disinfection Byproduct
DFFE	Department of Fisheries, Forestry, and Environmental Affairs
DOC	Dissolved Organic Carbon
DWS	Department of Water and Sanitation
EC	Electrical Conductivity, measurement of salt content in water, in milli-Siemens/metre (mS/m)
FDA	Food and Drug Administration
GAC	Granular Activated Carbon
HACCP	Hazard Analysis and Critical Control Point
IAP	Independent Advisory Panel for the Faure NWS
ISO	International Standards Organisation
LRV	Log Removal Value
MBR	Membrane Bioreactor
MIT	Membrane Integrity Test
N/A	Not Applicable
NDMA	N-Nitrosodimethylamine, a DBP
NEMA	<i>National Environmental Management Act 107 of 1998</i>
NTU	Nephelometric Turbidity Units
NWA	<i>National Water Act 36 of 1998</i>
NWRI	National Water Research Institute (USA)
NWS	New Water Scheme
ORP	Oxidation-Reduction Potential
PAH	Poly-aromatic hydrocarbons
PAJA	<i>Promotion of Administrative Justice Act 3 of 2000</i>
PRW	Purified Recycled Water
QCRA	Quantitative Chemical Risk Assessment
QMRA	Quantitative Microbial Risk Assessment
SABS	South African Bureau of Standards
SANAS	South African National Accreditation System
SANS	South African National Standard
THM	Trihalomethanes
TKN	Total Kjeldhal Nitrogen
TOC	Total Organic Carbon
UF	Ultrafiltration
UV	Ultraviolet
VOC	Volatile Organic Carbon
WHO	World Health Organisation
WRC	Water Research Commission
WSP	Water Safety Plan
WTP	Water Treatment Plant
WWTW	Wastewater Treatment Works

Chapter 1: Introduction and Background

This Chapter outlines the background to the Faure New Water Scheme (NWS) of the City of Cape Town (CoCT or 'the City'), and discusses water reclamation in the urban water cycle, international water reclamation schemes, the establishment and the scope of work of the IAP, the areas of expertise of its members, a timeline of the tasks undertaken by the IAP to date, the purpose of this Report, and a summary of its structure.

Background

The CoCT became known around the world as the city that, after enduring a severe drought (the worst on record) between 2015 and 2018, narrowly avoided 'Day Zero' (running out of water supply for domestic use) through the implementation of significant water conservation measures, including restrictions on its residents. To prevent having to face a similar challenge in future, the City developed a Water Strategy, "*Our Shared Water Future*", which was published for public comment in March 2019, and finalised in 2020. This Strategy provides a roadmap towards a water resilient future for the citizens of Cape Town. In this Strategy, the City outlined its commitments to secure water supply for the future, which included the following criteria for decision-making in this regard:

- Ensure safe access to water and sanitation;
- Ensure the wise use of water, and promote water conservation;
- Ensure sufficient, reliable water from diverse sources, including groundwater, desalinated water, and advanced treatment of treated effluent to reclaim this water for domestic reuse; and
- Become a water sensitive city, making optimal use of different water resources and implementing diversified infrastructure that are based on sound scientific principles and that are cost-effective and affordable.

With regard to different water resources, scientific aspects such as the hydrological cycle (natural evaporation, condensation, precipitation, and the collection of precipitation in streams, lakes, the ocean, or seepage to aquifers), have to be considered. With regard to diversified infrastructure, the components of the **Urban Water Cycle** (engineered methods that ensure water supply and sanitation service delivery to urban areas) have to be taken into account. A typical urban water cycle is depicted in **Figure 1 below**.¹

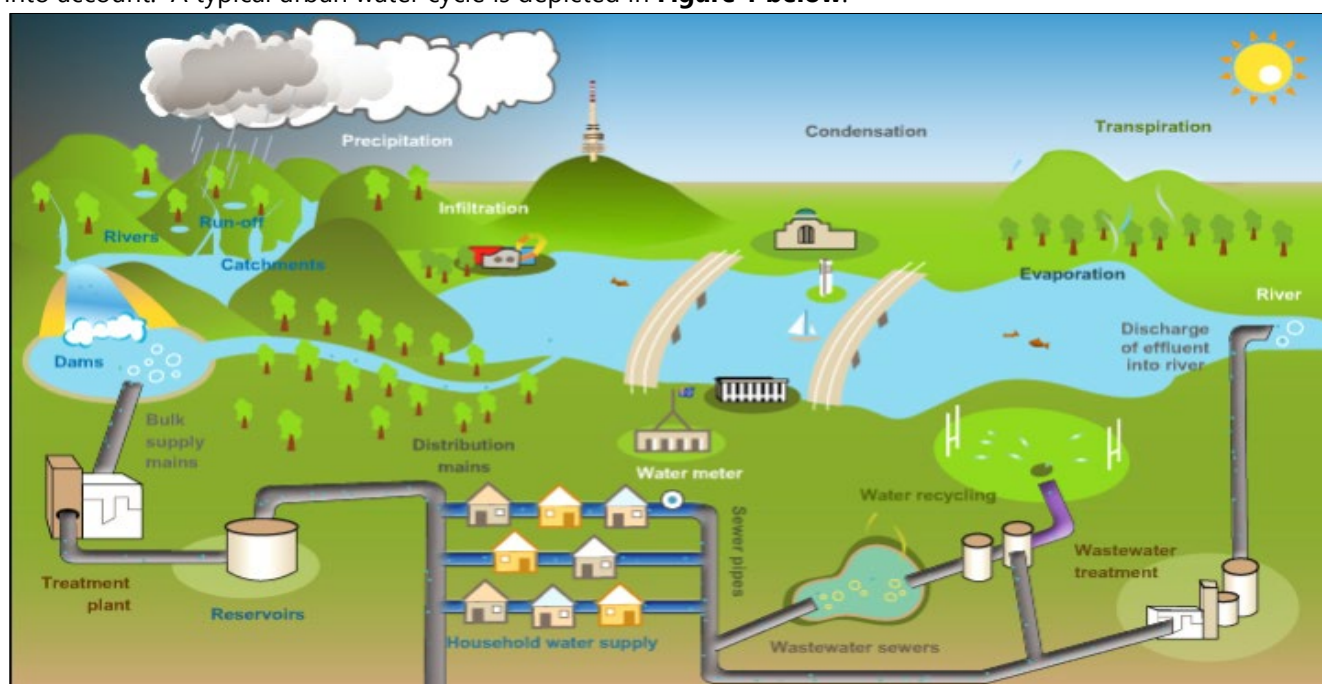


FIGURE 1: THE URBAN WATER CYCLE

¹ Catalonia Polytechnic University, 2006. <https://www.iri.upc.edu/project/show/90>

The typical urban water cycle consists of eight (8) components, namely:

- 1) **Sources:** Water to be used for drinking supplies are sourced from somewhere. Traditionally, sources include surface water such as dams, lakes, or rivers, or underground from springs, wells, or boreholes drilled into aquifers.
- 2) **Treatment:** Because water from natural sources may contain substances or organisms that could be harmful to human health, or that could interfere with industrial processes, it has to be treated at a Water Treatment Plant (WTP) before it can be used for domestic or certain industrial purposes. Typical conventional treatment processes entail chemical coagulation or flocculation, sedimentation, stabilisation, filtration, and disinfection.
- 3) **Storage:** After treatment and sufficient disinfection, the water is distributed to reservoirs or water towers in the city. Water is pumped from reservoirs to households, while water towers use gravity to make sure the water has the required pressure for distribution to households, businesses, and industries.
- 4) **Distribution:** From these reservoirs, water is further distributed for use. A disinfectant residual must be maintained throughout the distribution system to control viruses, bacteria, and protozoan parasites and ensure the water remains safe for human consumption.
- 5) **Use:** Consumers use the distributed water everyday for domestic, industrial, agricultural, manufacturing, and other purposes, and payment for their use cover the costs for the treatment and distribution of the water.
- 6) **Wastewater Collection:** After various uses, water is collected via drains and sewers to prevent the uncontrolled flow and discharge into streets and rivers where it could pose a health risk. Collected wastewater is conveyed through a sewerage reticulation system, using gravity or pumps to a Wastewater Treatment Works (WWTW).
- 7) **Wastewater Treatment:** Because natural processes, and especially the human use of water adds chemical and microbiological contaminants to the water that could pose a risk to human health or to the environment, it requires treatment by means of physical, chemical, and biological processes at the WWTW.
- 8) **Discharge:** In a typical urban water cycle, the treated wastewater from the WWTW is discharged back into the environment, and becomes part of the hydrological cycle again, to be used as a water source elsewhere.

Many cities around the world have realised that treated effluent from a WWTW is an important alternative water source, and when further treated, this water can be reclaimed as a 'new' water source to supplement existing insufficient freshwater sources. Reclaimed water is sometimes also referred to as Purified Recycled Water (PRW).

Figure 2 maps some cities which have successfully implemented such water reclamation schemes.²

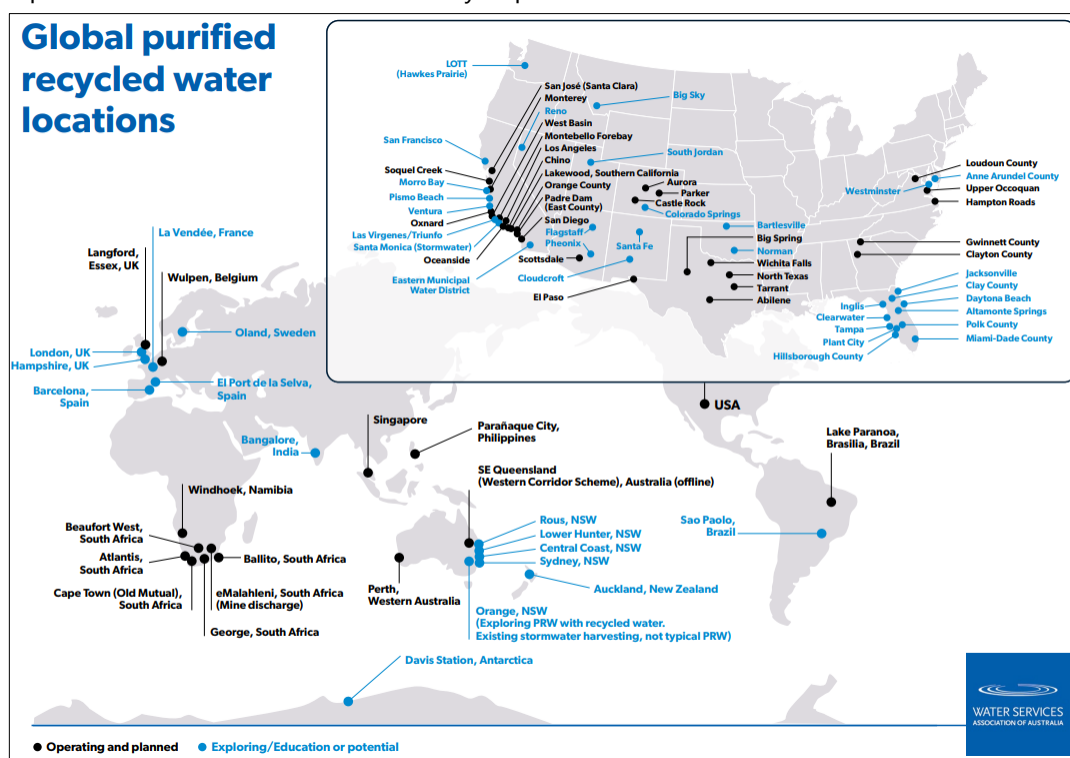


FIGURE 2: USE OF RECLAIMED WATER IN CITIES AROUND THE WORLD, 2023 (WSSA)

² Map courtesy of the Water Services Association of Australia (WSSA), who is currently developing an interactive global water reclamation map, and it is up to date as of 6 June 2024.

Considering the decision-making criteria as captured in its Water Strategy, the CoCT identified a number of options to augment its current raw water supply sources, including from utilisable groundwater resources; maintenance of infrastructure to reduce leaks and losses; desalination of sea water; and removal of alien vegetation. These options have already been implemented throughout the City since 2018. One option that would augment raw water supplies, which has been identified but not yet implemented, relates to the further treatment of final treated effluent from a WWTW through further treatment at an Advanced Water Treatment Plant (AWTP) to produce 'reclaimed water' to be treated at an existing WTP to be suitable for human consumption. This type of reclamation effectively adds a shortcut to the urban water cycle, as it implies that, rather than releasing treated effluent from a WWTW back into rivers and the ocean and waiting for it to return as rain, it is redirected to an AWTP, so that it can be treated and reused.

The CoCT has been investigating the feasibility of implementing a water reclamation scheme since the 1990s, and, following the severe drought of 2015 – 2018, one option has been identified as the most cost-effective major water project to augment the drinking water supply for the City by an additional 70 – 100 Mℓ/day. This option entails pumping treated wastewater from the Zandvliet WWTW for 5 km to a new AWTP (referred to as the Faure NWS), which will be located next to the existing Faure WTP. The Faure WTP currently receives and treats water from the Steenbras and Theewaterskloof Dams. After advanced treatment of wastewater at the Faure NWS, the reclaimed water will be blended with source water from these dams, and further treated at the existing Faure WTP, prior to distribution to reservoirs throughout the City for domestic use.

Terminology used in this Report regarding water reclamation in relation to the relevant suitability of water quality for human consumption, and the proposed shortcut in the urban water cycle for the CoCT, is illustrated **below**.

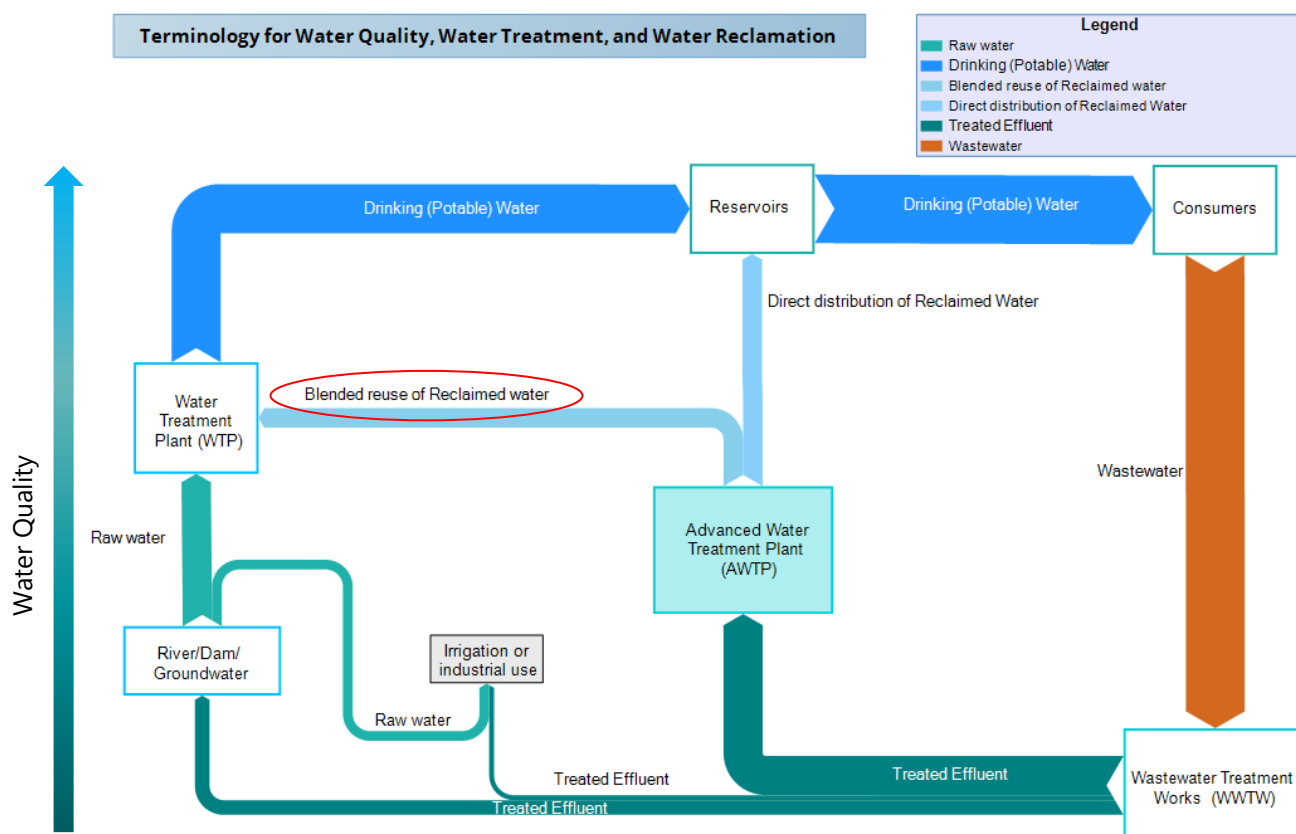


FIGURE 3: TERMINOLOGY ASSOCIATED WITH WATER RECLAMATION IN THE URBAN WATER CYCLE

As there are potential risks associated with a water reclamation scheme on such large scale, the project team of the CoCT (CoCT officials and their consulting engineers and specialists from Zutari, with significant experience in designing water treatment infrastructure and systems) partnered with the Water Research Commission (WRC) for coordination and provision of research, development, and innovation to support the investigation and implementation of the Faure NWS.

Scope of Work and Areas of Expertise of the IAP

The Faure NWS is currently in the planning and design stage, with an aim to start producing water in 2028, which gives an opportunity for specialists to influence the design and implementation of the Faure NWS. The WRC therefore established an Independent Advisory Panel (IAP) in July 2022 to provide expert scientific, technical, engineering, project implementation, and related best practice advice regarding the Faure NWS to the CoCT.

The eleven (11) members of the IAP were selected based on their wide-ranging expertise and extensive experience in water treatment, water reclamation schemes, water governance, and water-related communication. A short summary of the biographies of the members of the IAP is contained in **Annexure “A”**, in Table 4 on page 32, and Table 5 on page 34 summarises the respective areas of expertise of IAP members in relation to water reuse.

The activities of the IAP to date entailed the review of project design and other project-related documents produced by the CoCT and its project team (Zutari); drafting of comments on these documents; site visits at the Faure WTP, Zandvliet WWTW, and City laboratories; meetings; and workshops, as discussed in the next paragraph.

Timeline of IAP Tasks undertaken to date

The timeline in **Figure 4 on page 5** summarises the tasks undertaken by the IAP since its establishment in July 2022 to date, indicating meetings held on the left, and specific actions and tasks on the right. As is evident from the timeline in **Figure 4**, the work of the IAP to date entailed two (2) main tasks. Task 1 entailed an initial review of project documents produced by the project team of the CoCT (Zutari), with comments from the IAP discussed at an in-person Workshop held with representatives of the CoCT and their project team of the in November 2022, following which the CoCT and their project team were tasked to further investigate a number of aspects.

For Task 2, the IAP members were organised into three (3) thematic working groups, based on their areas of expertise and experience, to evaluate further inputs received from the CoCT and their project team, as follows:

- **Working Group #1: Regulatory Aspects and public engagement**, Dr Sarah Slabbert (chair), Associate Prof Kevin Winter, Carin Bosman, and Ian Law (coordinator).
- **Working Group #2: Source water understanding, protection and water and sanitation safety planning**, Dr Esper Ncube and Bettina Genthe, (co-chairs), Prof Fred Leusch, Jurgen Menge, and Ian Law (coordinator).
- **Working Group #3: AWTP design**, Megan Schalkwyk, Troy Walker, Jurgen Menge, James Crook, and Ian Law (coordinator).

Each Working Group evaluated the additional inputs received from the project team of the CoCT, and the collective feedback on these inputs was discussed with the relevant divisions of the CoCT and their project team during the in-person Workshop held from 4 – 8 December 2023 in Cape Town.

During the December 2023 Workshop, the CoCT representative for Bulk Water, Mr Mike Killick, enquired whether the IAP would be comfortable with the implementation of the Faure NWS based on the input received from the CoCT and their project team. As the CoCT and their project team had taken inputs that the IAP made during various meetings into account, it was decided that the IAP would compile a summary report that captures aspects considered by the IAP as key and critical to ensure the successful implementation of the Faure NWS.

It is important to note that the aspects captured in this Report do not reflect all aspects that the IAP has raised during its deliberations, as many aspects raised during the initial workshop had been addressed by the CoCT and their project team during subsequent iterations and engagements.

2022/2023 IAP Report on the Faure NWS

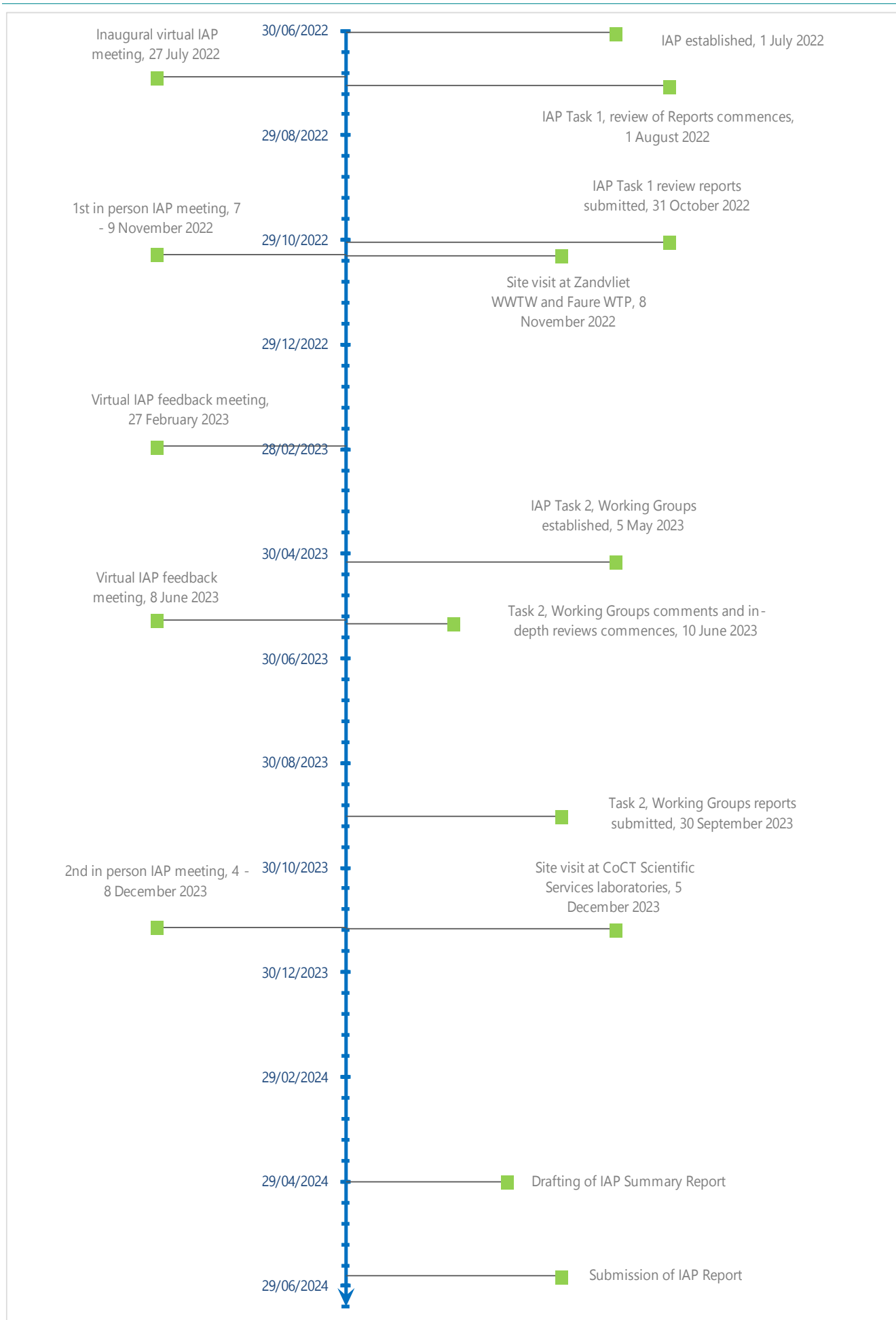


FIGURE 4: TIMELINE OF IAP TASKS UNDERTAKEN SINCE ITS INCEPTION TO DATE

Purpose of this Report

The **purpose** of this Report is to summarise aspects that the IAP considers as key and critical to in respect of the design and the successful implementation of the Faure NWS. These findings and recommendations are based on the information and documents made available to the IAP by the CoCT and their project team up to 27 April 2024, and a list of documents reviewed and considered is contained in **Annexure “B”**.

It is not the purpose of this Report to summarise all the information associated with the Faure NWS and its detailed designs and implementation plans that have been considered and reviewed. The document should not be used as an engineering report, but rather as a report containing the opinions of the members of the IAP as peer reviewers of the project. In addition, the IAP, by its nature, is an advisory panel, and it is appreciated that the CoCT can take cognisance of the advice given by the IAP but need not necessarily implement all advice received. Therefore, only the aspects that are regarded as key and critical by the members of the IAP that would, in the opinion of the IAP, determine the successful implementation of the Faure NWS, are covered in this Report.

Report Structure

This Report is structured as follows:

- **Chapter 1** of the Report (this chapter) contains an introduction, outlining the background to the Faure NWS, the establishment and the scope of work of the IAP, the areas of expertise of its members, a timeline of the tasks undertaken by the IAP to date, the purpose of this Report, and a summary of its structure.
- **Chapter 2** summarises the current status relating to the design and implementation of the Faure NWS as understood by the IAP based on the information and documents made available to the IAP to date, highlighting, where relevant, the key and critical components, that in the opinion of the IAP, would lead to successful implementation of the Faure NWS. These key elements relate to water and sanitation safety planning, specifically source water protection, both discharges in the upstream catchment of the Zandvliet WWTW and at the Zandvliet WWTW itself; the design of the Faure NWS to deliver water of a quality that is suitable for human consumption and use, as measured by the establishment of treatment targets and the selection of reference parameters for operational monitoring; regulatory aspects and internal institutional arrangements and oversight; as well as communication, including external public engagement, awareness, and education.
- **Chapter 3** summarises the key findings and recommendations of the IAP that are regarded as essential to ensure the successful implementation of the Faure NWS.

There are also five (5) Annexures attached at the end of this Report, which expand on some of the content of the Report, where relevant.

Chapter 2: Key Aspects for the Faure NWS

This Chapter summarises the current status relating to the design and implementation of the Faure NWS as understood by the IAP based on the information and documents made available to the IAP by the CoCT and their project team up to 27 April 2024, highlighting the key and critical components, that in the opinion of the IAP, would lead to successful implementation of the Faure NWS. These key elements relate to water and sanitation safety planning, specifically source water protection, both discharges in the upstream catchment of the Zandvliet WWTW and at the Zandvliet WWTW itself; the design of the Faure NWS to deliver water of a quality that is suitable for human consumption and use, as measured by the establishment of treatment targets and the selection of reference parameters for operational monitoring; regulatory aspects and internal institutional arrangements and oversight' as well as communication, including external public engagement, awareness, and education. These aspects are discussed in turn below.

Water and Sanitation Safety

It is of paramount importance that a scheme such as the Faure NWS meticulously address a multitude of water quality objectives to ensure the protection of public health. These water quality objectives include addressing two main types of health risks, namely:

- Chronic health risks posed by both inorganic chemicals and organic chemical substances, including chemicals of emerging concern (CECs), such as pharmaceuticals, personal care products, radionuclides, phytosanitary products (pesticides and herbicides), volatile organic carbons (VOCs) and semi-volatile organic carbons, potential carcinogenic substances such as polyaromatic hydrocarbons (PAHs), soluble organics, organics causing discolouration, and disinfection byproducts (DBPs) such as trihalomethanes (THMs), N-Nitrosodimethylamine (NDMA), bromate, assimilable organic carbon (AOC), or biodegradable organic carbon (BDOC), which cause regrowth in the distribution network; or corrosion and hardness which cause damage to distribution infrastructure; and
- Acute risks posed by microorganisms and pathogens (viruses, protozoa, and bacteria): Viruses, known for their ability to cause rapid outbreaks of waterborne diseases, can spread quickly and lead to widespread illnesses. Protozoa, including pathogens like *Cryptosporidium* and *Giardia*, are highly resilient and resistant to conventional treatment methods, making them critical targets for removal or inactivation to prevent gastrointestinal infections. Bacteria, including pathogenic strains such as *Campylobacter*, *Salmonella typhi* or *Vibrio cholera*, can also result in severe illnesses and can develop resistance to antibiotics, exacerbating health risks.

A Water Safety Plan (WSP) is a plan to ensure the safety of drinking water through a comprehensive risk assessment and risk management approach that encompasses all steps in a drinking water supply chain, from catchment to consumer. The World Health Organization (WHO) considers developing a WSP using a risk-based approach as the most reliable and effective way to manage drinking water supplies to safeguard public health.

Such a risk-based approach should follow the principles of the Hazard Analysis and Critical Control Point (HACCP) methodology, which follows a multi-barrier approach. The multiple barrier approach is designed to remove physical, chemical, and microbial constituents from water, and is based on the concept of redundancy to ensure that failure of a barrier does not necessarily compromise the ability of the whole system to achieve treatment targets, because several independent barriers are combined in series. In the event of the failure of a single barrier, it does not necessarily result in the failure of the entire system and allows for timely corrective action to be taken.

A **multi-barrier approach** therefore considers all threats (natural and anthropogenic) and establishes multiple barriers to either eliminate or minimize their impacts, which include the following:

- **Source protection:** selecting the best available source for drinking water, and protecting the source against contamination, which implies keeping the source water as clean as possible through catchment-based risk planning that considers the vulnerability of water resources to potential contamination by upstream anthropogenic activities such as industries, business, human habitation, etc.;

- **Effective treatment:** using effective water and wastewater treatment technologies to remove or inactivate contaminants through coagulation, flocculation, filtration, ozonation, activated carbon and/or membrane ultrafiltration, ultraviolet irradiation, and chlorination, and ensuring that the treatment technology itself does not create contamination in the system through the generation of DBPs;
- **Distribution system protection:** preventing water quality deterioration in the water distribution system by protecting treated water from intrusion of contaminants and ensuring appropriate free chlorine residuals throughout the system to maintain disinfection; and
- **Effective monitoring:** implementing automated control instrumentation to give alarm warnings if predetermined trigger values or levels are at risk of being exceeded (for example pre-determined concentration limits of microbiological species and CECs), as well as dedicated laboratory monitoring, to facilitate intervention that ensures water is produced that meet these predetermined specifications; and
- **Contingency responses:** ensuring early responses to adverse conditions (e.g., deteriorating water quality) with specially designed and well-rehearsed contingency plans.

Control of source water is the **first** barrier in a multi-barrier approach, and thus critical for the effectiveness of a multi-barrier system. The objective of source water protection is to preserve or enhance source water quality and quantity within water bodies that are current, or are likely to be future, sources of drinking water supply. Source water protection therefore refers to the actions and interventions taken to reduce risks of contamination, depletion and to enhance source water quality and quantity. Such actions would depend on the level of risk posed to the source water, and could include control through regulations, bylaws, fines, or site-specific interventions.

Two aspects are of specific note with regard to Source Water Protection for the Faure NWS, namely the effective control over the effluents discharged into the Zandvliet WWTW for treatment, and effective treatment of incoming effluents at the Zandvliet WWTW. Details regarding these aspects are further discussed in the next two sections.

Source Water: Upstream Catchment

The CoCT has a WSP in place, which was reviewed by Working Group 2, and presented to the IAP during its December 2023 Workshop. The WSP addresses the abovementioned multi-barrier aspects but requires updating to address the new challenges and threats identified that potentially could pose a risk to the Zandvliet WWTW as a source of feedwater for the Faure NWS. Working Group 2 of the IAP developed a model to assist the CoCT with its source water protection planning interventions to ensure that substances and micro-organisms that could jeopardise the operation of the Faure NWS do not enter the system, both currently, and in the future, and this model is illustrated in Figure 5 below.

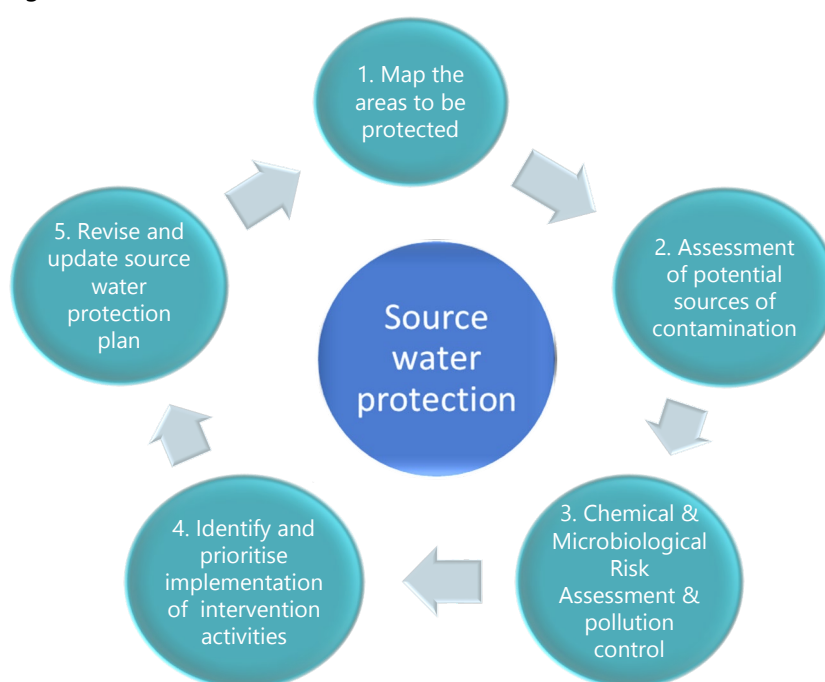


FIGURE 5: PROPOSED SIMPLIFIED SOURCE WATER PROTECTION MODEL

In respect of progress made in addressing the elements of this model, the following are of note:

- Both a quantified chemical risk assessment (QCRA) and a quantified microbial risk assessment (QMRA) have been undertaken on the final treated effluent from the Zandvliet WWTW.
- The City has also made some progress with the assessment of potential sources of contamination, including the categorisation of the industries in the upstream catchment based on their industrial codes, and the list of identified industries are attached as **Annexure "C"**. A list of chemicals that has been analysed for in the incoming wastewater into the Zandvliet WWTW is attached as **Annexure "D"**.
- Although the City has initiated the mapping of the upstream catchment areas where protection intervention is warranted, this mapping requires updating based on the characterisation of potential problematic effluents into the source water, which should be undertaken following a catchment audit.

The IAP is of the opinion that the assessment of potential sources of contamination requires further attention. Firstly, a QCRA has not yet been undertaken to characterise and assess the potential risk posed by the actual effluents from individual industrial premises that discharges into the Zandvliet WWTW, and this is considered necessary to identify the potential presence of the CECs mentioned above in such incoming effluent streams. The outcome of this QCRA should indicate the type and nature (composition) of the upstream industrial effluents that are being discharged into the sewers that feed the Zandvliet WWTW from its upstream catchment, as well as an assessment of the risks posed by each of these upstream effluents, identifying interventions to manage these risks, and incorporating the identified risks into a regularly updated WSP.

Based on the outcome of both the QCRA on the incoming streams and the QCRA on the final treated effluent from the Zandvliet WWTW, the IAP recommends that a list of indicator parameters, or surrogates be developed that is specifically tailored to critical contaminants contained in the effluents of upstream industries that have the potential to jeopardise the operation of both the Zandvliet WWTW and the Faure NWS, that would represent groups or classes of the organic chemicals listed in **Annexure "D"**. In this manner, a cost-effective monitoring programme for these indicators or surrogate components can be developed and implemented (refer for example to the list of surrogate chemical parameters developed for a plant in Perth, Australia,³ attached as **Annexure "E"**). This monitoring programme should furthermore include the installation of on-line sensors at key nodal points that would monitor for the presence of indicator parameters in the collection system to warn of illegal or abnormal discharges to sewer and provide advance warning to the WWTW operations team of potential adverse impacts on operations. Provision should be made for regular validation and maintenance of these on-line instruments.

In this respect, the IAP recommends that full financial and institutional support be given to both the Scientific Services laboratories, who may need to develop methods to facilitate the laboratory analysis for specific parameters that are identified in upstream industrial effluents (based on the outcome of the upstream QCRA), and the Pollution Control section of the City, who need to prioritise pollution control intervention activities where non-compliances are identified that could adversely affect the operation of the Zandvliet WWTW and the Faure NWS.

In addition, pollution control intervention activities should include actions to identify and prevent illegal discharges, such as the installation of cut-off valves and holding tanks at specific high-risk industrial premises itself, where effluent can be stored should trigger values of critical components be exceeded. The implementation of these controls should be facilitated under an updated Wastewater and Industrial Effluent Bylaw, which should also make provision for the publication and implementation of a penalty system to impose a fine when expected or agreed trigger values are being exceeded.

Secondly, the QMRA that was conducted by the CoCT project team, which was used to derive treatment targets for the AWTP (refer to the discussion on page 13), was based on available literature, and not on results obtained from the Zandvliet WWTW, for the reasons discussed in the next paragraph.

³ Law, I.B., 2022. *Source Control in Advanced Reuse Applications – International Trends*. Paper presented to the Trade Waste Control Group of Water Services Association of Australia (WSAA), 27th July 2022

Source Water: Zandvliet WWTW

The source water for the Faure NWS is the treated effluent produced by the Zandvliet WWTW, which receives enough wastewater, mostly from homes, schools and business, to augment the water supply of the City. Treatment of this wastewater at the Zandvliet WWTW can therefore be regarded as the second main barrier in the multi-barrier system. The three (3) main treatment processes at the Zandvliet WWTW are:

- **Membrane Bioreactor (MBR):** An MBR process combines a microfiltration membrane unit with a suspended growth bioreactor such as activated sludge, retaining salts and solid particles.
- **Conventional Activated Sludge (CAS):** A CAS process utilises aerobic micro-organisms that can digest organic matter in wastewater, and are then wasted as a sludge, removing non-active microbes from the system. This process reduces organic contaminants in the water.
- **Biological Nutrient removal filters (BNR):** This process removes the nutrients (nitrate and phosphate) by converting nitrogen present as ammonia (NH_3) to nitrogen gas (N_2) by ammonia-oxidising bacteria; and by the bioaccumulation of phosphate in biomass through polyphosphate-accumulating bacteria organisms.

These three processes function in two streams: the MBR-stream, which effectively removes biological nutrients, and the CAS/BNR stream, where the CAS treatment is augmented with the BNR-treatment (see Figure 6 on page 11). A refurbishment of the Zandvliet WWTW was completed in 2023 and various aspects relating to its operation are currently being verified. Once fully operational, a formal validation of the WWTW will be undertaken to determine additional process optimisation requirements, after which the final effluent can be assessed for the purposes of a QMRA. A Green Drop Audit will also be undertaken by the national regulator, the Department of Water and Sanitation (DWS) once the WWTW has been optimised. The Green Drop system assigns two scores, namely an overall Green Drop Score, of which a minimum of 90% should be achieved to qualify for Green Drop status, and a Cumulative Risk Rating (CCR).⁴

It is the opinion of the IAP that the Zandvliet WWTW should achieve and maintain a Green Drop status above 90% and a CCR of below 25% to be considered as a suitable source water for the Faure NWS.

Faure NWS: Design, Treatment Targets, and Measurement

As discussed above, the meticulous design and implementation of robust treatment processes capable of effectively removing chemicals and neutralizing microorganisms are essential in a water reclamation project. This section therefore discusses the proposed design of the Faure NWS, the proposed treatment targets to be achieved by this design for the proposed Faure NWS, and the measurement of performance against these treatment targets.

Design of the Faure NWS

The third component of the multi-barrier system entails treatment at the Faure NWS, with the objective of delivering water of a quality that is suitable for human consumption and use to the residents of the CoCT. The multi-barrier approach has also been incorporated in the design of the AWTP at the Faure NWS, which is based on the concept that each contaminant class (both chemical and microbiological) has at least two active barriers in place at any one time.

The design for the AWTP at the Faure NWS consists of six (6) treatment processes, known as a treatment train, as illustrated in Figure 6 on page 11, which implies that there are a total of eight (8) barriers in place before the reclaimed water reaches the Faure WTP.

⁴ A CCR assigned during a Green Drop Audit indicates the prevailing risk of a WWTW exceeding its operating capacity as a percentage of a maximum possible risk, and a 25% CCR value means the WWTW has a low risk to exceed its capacity or discharge limit values.

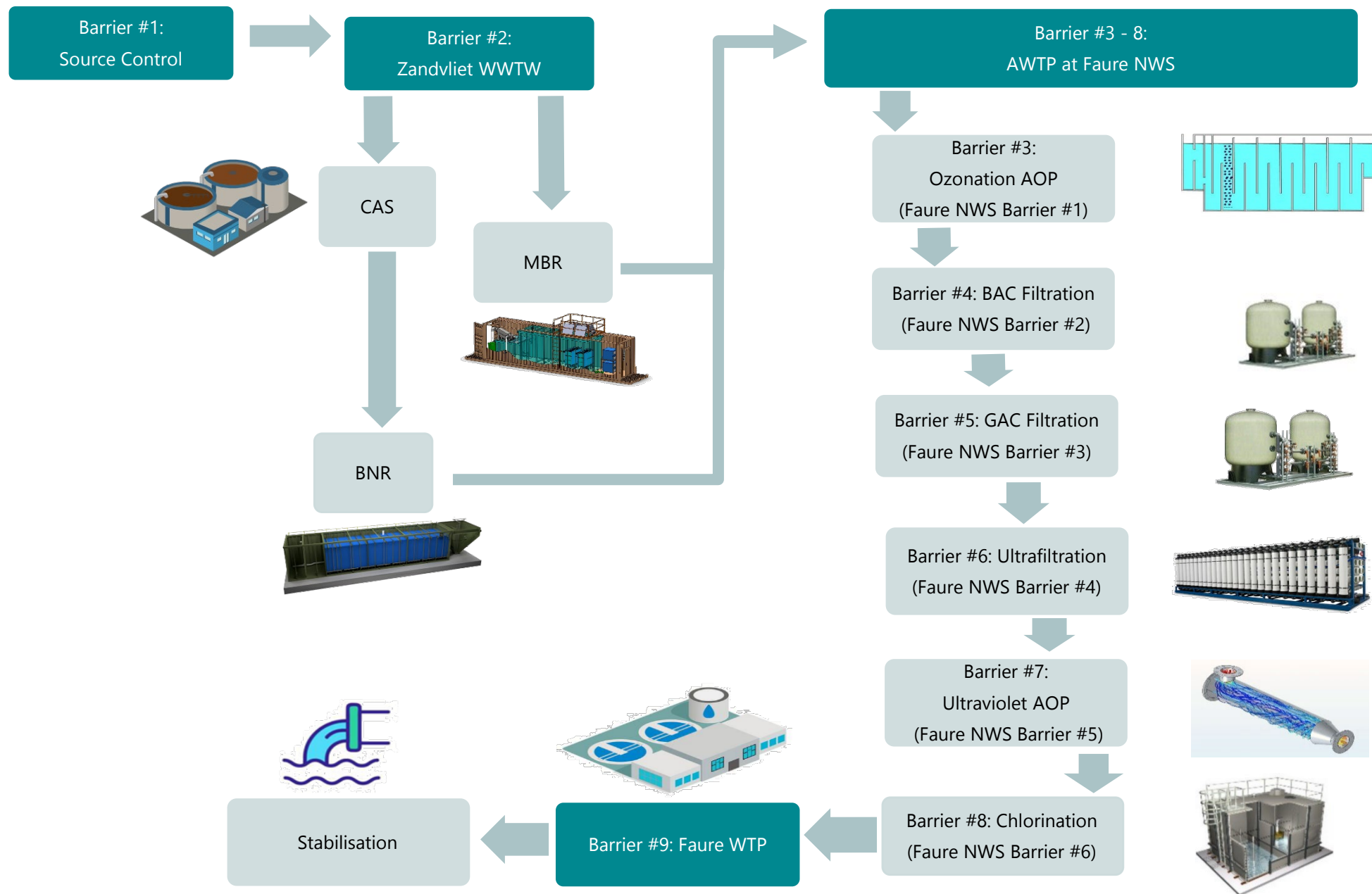


FIGURE 6: PROPOSED MUTI-BARRIER TREATMENT TRAIN FOR THE PROPOSED WATER RECLAMATION SCHEME

Each of the six (6) treatment processes at the AWTP plays a specific role in treating the source water to a quality suitable for human consumption, which can be summarised as follows:

- **Ozonation:** The Ozone reactor is an advanced oxidation process (AOP) that targets Dissolved Organic Carbon (DOC) which is mostly associated with CECs. Ozone is a very strong oxidant, and it works by breaking the long carbon chain bonds of organic substances (including CECs) into shorter carbon chain bonds that can more readily be removed via a biological activated carbon (BAC) filtration process. It also contributes to disinfection. If testing of the Zandvliet effluent indicates the presence of bromide, a dose of monochloramine prior to ozonation will prevent the formation of bromate, a DBP.
- **Biologically Activated Carbon (BAC) Filtration:** A BAC filtration process entails the removal of DOC associated with shorter carbon chains (such as the breakdown products of CECs) through biological activity on the carbon in the filter contact beds. This is considerably enhanced by the preceding dose of ozone and is often referred to as a single process: "ozone-BAC".
- **Granular Activated Carbon (GAC) Filtration:** Activated carbon is an effective adsorbent because it is a highly porous material and provides a large surface area to which contaminants readily adsorb. GAC filtration is thus used to adsorb natural organic compounds, semi-volatile organics, VOCs, synthetic organic chemicals, trace organics, and taste and odour compounds from water. The GAC step will also assist with the removal of DBPs, should it be a potential concern if a mono-chloramine dosing step is introduced to mitigate bromate formation.
- **Ultrafiltration (UF):** UF uses a membrane barrier to reject particles as small as 0.01 microns. This makes it a very good barrier for bacteria, cryptosporidium, parasites and some viruses.
- **Ultraviolet (UV) AOP:** This treatment step serves as the final barrier for the removal of organics and pathogenic material up-stream of the Faure WTP. It uses a very high dose of UV to destroy persistent organic chemicals such as NDMA via photolysis. A dose of hydrogen peroxide (H_2O_2) is also added, which converts under the high UV radiation to hydroxyl radicals, which in turn oxidize other persistent compounds such as 1,4 dioxane. The UV AOP treatment step therefore targets the selected surrogate DBPs and CECs, i.e., NDMA and 1,4 Dioxane, as well as pathogens, viruses, *cryptosporidium*, *giardia* and other bacteria through two (2) mechanisms.
- **Chlorination:** This treatment step is the final barrier for the removal of pathogens and entails further disinfection of the treated water by adding chlorine, and the effectiveness of this process depends on the dose of chlorine and the contact time (CT) between the chlorine and the water.

The reclaimed water produced by the AWTP at the Faure NWS will be blended with raw water from the Steenbras and Theewaterskloof Dams at an 80:20 ratio prior to further treatment at the existing Faure WTP. After treatment at the existing Faure WTP, the produced water will go through a **stabilisation** process to balance its buffering capacity (which prevents scaling or corrosion of pipes), prior to distribution to reservoirs throughout the City for domestic use. The IAP recommends that the ability of the existing stabilisation plant at the Faure WTP to also handle the stabilisation of the treated reclaimed water be investigated and verified.

Although not part of the scope of work of the IAP, the IAP notes that the processing of final treated effluent from the Zandvliet WWTW through the Faure AWTP for the purposes of producing reclaimed water to be blended for further treatment at the Faure WTP, will reduce the pressure on the Kuils River, which implies a positive impact from an aquatic biodiversity perspective.

The ability of the design of the AWTP to facilitate the production of water by the Faure WTP that will meet the requirements for domestic use is determined by monitoring the performance of the components of the AWTP against identified treatment targets, as discussed in more detail below.

Treatment Targets for the Faure NWS

In South Africa, the quality of water supplied for domestic use is prescribed by the SANS 241 Drinking Water Standard,^{5,6} established by the South African Bureau of Standards (SABS) and regulated under the *Water Services Act 108 of 1997*. This standard specifies numerical limits for drinking water, at the point of delivery, in terms of microbiological, physical, organoleptic, and chemical parameters based on the WHO guidelines for drinking water quality and is currently under review. Water produced by the CoCT must meet the requirements of SANS 241. However, the list of chemical and microbiological parameters currently contained in SANS 241 is based on those parameters typically expected in conventional raw water sources and does not cover all parameters that could be found in effluent from a WWTW. Although SANS 241 does contain some specifications relating to viruses, protozoa, and bacteria, it does not currently contain specifications for reclaimed water. There are currently no regulations in South Africa for the treatment of wastewater to produce reclaimed water. It is therefore insufficient to simply compare the reclaimed water with SANS 241 to determine either chemical risks, especially from CECs, or microbiological risks.

To address the lack of specifications in SANS 241 for reclaimed water and the absence of South African regulations for reclaimed water, the project team of the CoCT consulted international regulations and guidelines, including the methodology proposed by the WHO;⁷ the National Water Research Institute (NWRI) for the development of PRW criteria in the USA; the Surface Water Treatment Rule of the US Environmental Protection Agency (EPA);⁸ the California State Water Board; and the Australian guideline for PRW. The WHO recommends that because each water reclamation scheme will have its own unique circumstances and challenges, specifications should be derived on a site-specific basis.

To derive site-specific specifications for chemicals that could potentially be present in the treated effluent produced by the Zandvliet WWTW, and subsequently be contained in the reclaimed water produced by the Faure NWS, and that are not currently listed in SANS 241, the outcome of the QCRA undertaken on both the Zandvliet final treated effluent and the incoming effluent into Zandvliet as discussed under the **Water and Sanitation Safety** section above should be used to identify potential chemicals that could pose a health risk, and treatment targets should be developed for specific identified surrogate or indicator chemicals, for especially the chemicals listed in **Annexure “D”**.

From a microbiological perspective, these international requirements and guidelines are based on the same concept: The number of microbes present in a liquid, will be reduced through disinfection. To facilitate comparable and reproducible results, the reduction in the number of microbes must be measured. As the levels of some pathogens in water are below the detection limits of laboratory methods, the international best practice is to make use of Log Reduction Values (LRVs) to describe the level of disinfection achieved by a treatment process. LRVs are expressed as the logarithm (base 10) of the ratio between the concentration of the pathogen before disinfection and the concentration after disinfection. Each unit of LRV means reduction by a factor of ten: An LRV of 1 means that the microbes have been reduced by 90%, which implies that out of an original population of 100, only 10 microbes have survived. A reduction of 99% (in other words, LRV = 2), means that only 1 microbe of the

⁵ Standards South Africa, 2015. *South African National Standard (SANS) 241-1: Drinking Water. Part 1: Microbiological, Physical, Aesthetic and Chemical Determinants*. Edition 2. Standards South Africa, Pretoria.

⁶ Standards South Africa, 2016. *SANS 241-2: Drinking water. Part 2: Application of SANS 241-1*. Edition 2. Standards South Africa, Pretoria.

⁷ SANS 241 points water service providers and water service authorities to consult the WHO guidelines for dealing with other risks that are not covered by the standard, but that are relevant to the system.

⁸ The EPA proposes a tolerable risk of infection in 1 in 10,000 people per year. This target only focusses on the risk of actual infection and does not take the impact of an illness on a consumer into account.

original 100 has survived, and corresponds to the effect of washing with soap. In non-medical contexts, the term "*disinfection*" is used to describe a reduction of all microbes by a LRV of ≥ 4 , in other words by 99.99 %. In this case, if 10,000 microbes were originally present, one (1) organism might survive. In medical contexts the requirements for "*disinfection*" are stricter. According to the specifications of the American Society for Testing and Materials (ASTM) and the Food and Drug Administration (FDA) the term "*sterile filtration*" can only be used when the LRV is at least 7, in other words, 1 microbe out of 10,000,000 remains.

For the Faure NWS, the QMRA that was undertaken by the Zutari project team of the CoCT on the final treated effluent from the Zandvliet WWTW (refer to the discussion on page 8) was used to derive site-specific disinfection specifications (LRVs) to be achieved by the AWTP for enteric viruses, protozoa, and bacteria, by using the methodology proposed by the WHO. In this QMRA, assumptions with regard to wastewater pathogen concentration, consumer drinking water behaviour, dose-response relationships, risk of infection, and burden of disease were made when selecting the appropriate parameters for the QMRA. As each type of pathogen presents a different risk of infection and burden of disease to a population, reference pathogens were selected to represent each group when deriving LRV targets, as the choice of reference pathogens can influence the accuracy and relevance of the derived LRV targets. The reference pathogens for setting LRV targets for the Faure NWS were selected based on pathogens that are expected to be present in a typical South African wastewater, and pathogens for which sufficient data is available. The proposed LRVs for the removal of reference pathogens from raw sewage entering the Zandvliet WWTW to water suitable for human use in the distribution network of the CoCT, after blending and treatment at the Faure WTP, are 12.5 for Enteric norovirus, 11.5 for *Cryptosporidium*, 10 for *Giardia lamblia* (both protozoan parasites), and 9 for *Campylobacter* (bacterial reference pathogen).^{9,10} These LRV targets is determined by the following levels of disinfection claimed for each treatment process at the Zandvliet WWTW and the Faure NWS AWTP:¹¹

TABLE 1: CLAIMED LRVs FOR THE DIFFERENT TREATMENT PROCESSES

Facility	Treatment process	Enteric norovirus	<i>Cryptosporidium</i>	<i>Giardia lamblia</i>	<i>Campylobacter</i>
Zandvliet WWTW	MBR	1.5	2.0	2.0	4.0
	CAS	0.5	0.5	0.5	1.0
	BNR	1.0	1.5	1.5	1.0
	Aggregated	1.5	2.0	2.0	2.0
Faure NWS	Ozonation	4.0	0	4.0	4.0
	BAC	0	0	0	0
	GAC	0	0	0	0
	Ultrafiltration	0	4.0	4.0	3.0
	UV AOP	6.0	6.0	6.0	6.0
	Chlorination	2.0	0	0	2.0
	Aggregated	12	10	14	15
Total LRV claimed		12	11.5	10	9

In this respect, it is noteworthy that the LRVs published by the WHO are less stringent than those proposed for the Faure NWS, and were specified based on lower prevalences of viruses, protozoa, and bacteria than those found in South African wastewaters. This implies that the LRVs specified for the Faure NWS are higher (and thus more protective) than the LRVs published by the WHO. The approach is sound, and benchmarking the LRVs proposed by the project team are consistent with those derived in other jurisdictions (US/Australia).

⁹ Zutari, November 2023. *Faure New Water Scheme City of Cape Town: Derivation of LRV Targets*, Report number 501088-000-REP-KS-0002, page 26

¹⁰ Presentation entitled "*Critical Control Point Monitoring*" made available by Zutari on 8 June 2024

¹¹ Zutari, November 2023. *Faure New Water Scheme City of Cape Town: Claimed Pathogen Log Reduction Values*, Report number 501088-000-REP-KS-0003

Considering the above, the IAP notes that the LRVs that are claimed at each barrier at the Faure NWS are based on defensive evidence including peer reviewed research, established regulation or test data, and therefore supports the LRVs derived for reference pathogens for the Faure NWS, and recommends that the Faure NWS be designed and operated to meet these LRVs. The IAP qualifies its support for the claimed LRVs based on the understanding that the following assumptions are to be addressed:

- that a QMRA is to be undertaken on the actual final treated effluent from Zandvliet following its upgrade, to confirm the appropriateness of the reference pathogens and LRV targets selected for the Faure NWS;
- that ongoing water quality testing for identified reference pathogens be undertaken (which could include, in the medium term, a QMRA on the incoming effluents into the Zandvliet WWTW), to build a site-specific pathogen profile, against which claimed LRVs can be validated or revised targets specified where required;
- that, where relevant, the design of treatment processes should be upgraded to meet such revised targets prior to the finalisation of the design for construction; and
- that, during the testing phase of the Faure NWS, possible operational diversions are substantiated, the assumptions made in the development of the LRVs relating to the operation of the Faure NWS in accordance with HACCPs are verified, that the LRV credits claimed for especially the CAS and MBR at the Zandvliet WWTW are validated, and appropriately adjusted when operational conditions indicate that assumptions were not valid or sufficiently precautionary, or that LRVs claimed are not being met.

Measurement of Performance of the Faure NWS

To determine if LRVs claimed for each barrier are consistently being met, the efficiency of each of the different treatment processes is tested by means of the HACCP methodology. This entails establishing two (2) types of measuring points, namely (a) Critical Control Points (CCPs), defined as measuring parts of the treatment process that are designed to reduce, prevent, or eliminate a *human health hazard*, and (b) other important controls in the barrier system which are designated as Control Operating Points (COPs). The proposed measurement locations for the CCPs and the COPs at the Zandvliet WWTW, the Faure NWS, and the inlet to the Faure WTP are illustrated in Figure 7 on page 16.

CCP monitoring uses indicator or surrogate parameters that can preferably be measured online with sufficient sensitivity to demonstrate that the LRVs as specified are being met in real time. For CCP monitoring, three (3) sets of values are specified, i.e., a “target” level, an “alert” level, and an “action” level.¹² The current proposal entails that the failure to meet the “action” CCP limit values will result in an immediate diversion of water, discharging it back into the stream, in order to prevent “target” values from being exceeded. The “alert” limit value provides an early warning mechanism to prevent the need to divert the water if the issue can be corrected before it reaches the “action” level. This protocol thus ensures that only water that met the “target” CCP limit values are allowed through to the Faure WTP, to prevent contaminated water from entering the distribution network.

Although the measurement of indicator parameters at the proposed COPs is not aimed at identifying a human health hazard, it is regarded as critical to demonstrate to consumers to which degree the reclaimed water has been treated to meet the requirements to be used for domestic purposes, and if problems arose from the Faure NWS or not. Measurement of parameters at COPs will include both online sensors and routine monitoring. The parameters proposed by the Zutari Project Team to be tested online at the CCPs are listed in Table 2 on page 17, while both the recommended online and routine monitoring at the COPs are listed in Table 3 on page 18.

The IAP supports the location of and parameters to be tested for at the proposed CCPs and COPs, on the basis of the assumption that the recommendations of this report in respect of monitoring as discussed in more detail below, are to be implemented where relevant.

¹² Presentation entitled “FNWS CCCP Monitoring” made by Zutari on 6 December 2023

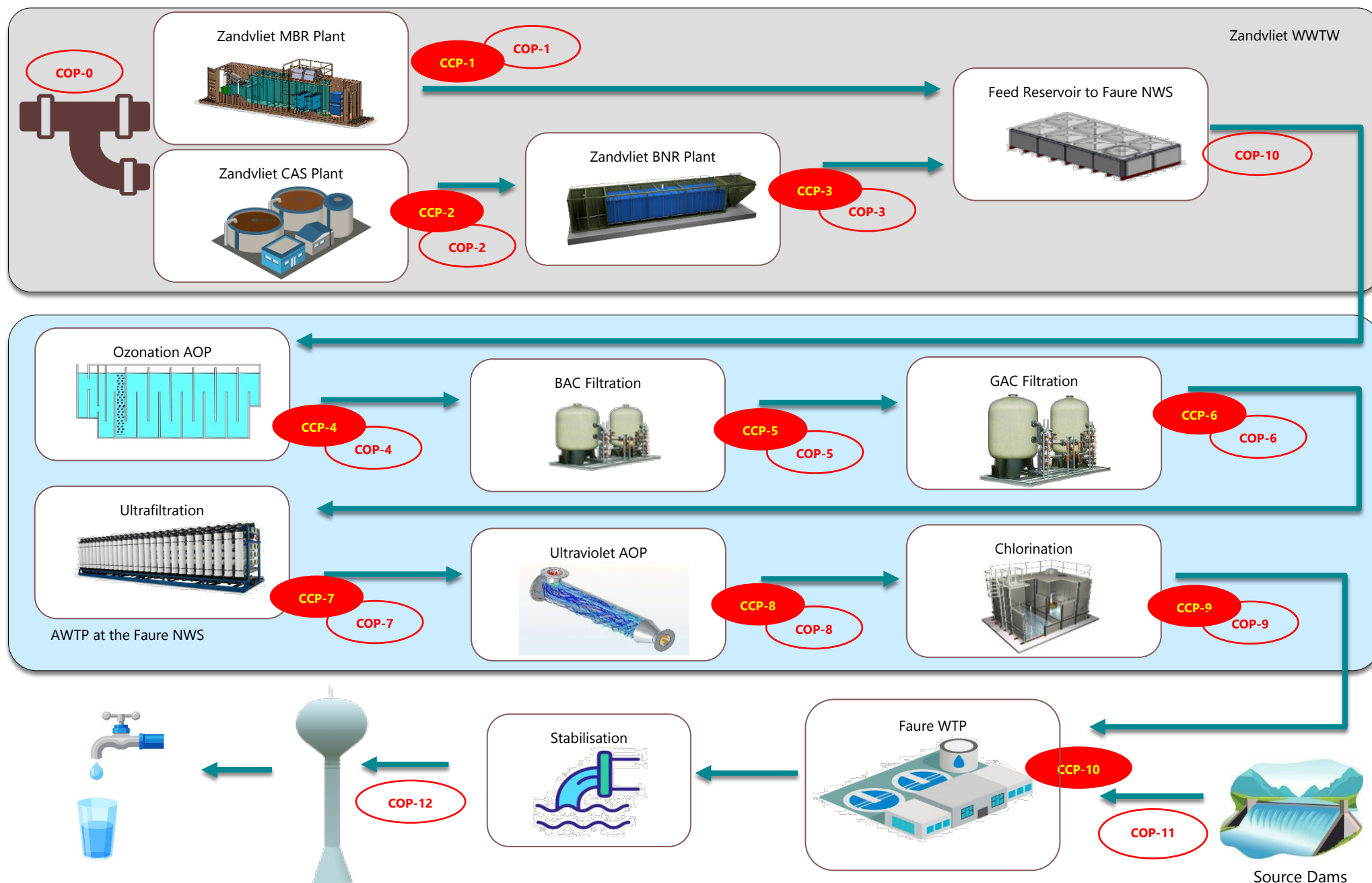


FIGURE 7: MEASUREMENT LOCATIONS FOR CCPs AND COPs AT THE ZANDVLIET WWTW AND THE FAURE NWS

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TABLE 2: PROPOSED ONLINE CCP MONITORING PARAMETERS, WITH HACCP ACTIONS TO BE TAKEN IF TARGETS ARE NOT MET

CCP #	Parameter	Unit	Ranges			Action	Objective
			Target	Alert	Trigger		
CCP-1: Zandvliet MBR	Turbidity	NTU	<0.5	0.7	>1.0	Water not taken to feed reservoir for Faure NWS, discharge to river at Zandvliet	To achieve LRVs of 1.5 for viruses, 2 for <i>Cryptosporidium</i> , and 2 for <i>Giardia</i> , <i>Campylobacter</i>
	Nitrate	mg/ℓ	<5.0	8.0	>10.0		
	Ammonium	mg/ℓ	<1.5	1.7	>2.0		
	EC	mS/m	<100	125	>150		
CCP-2: Zandvliet CAS	Turbidity	NTU	<10.0	12	>15	Water not taken to BNR, discharge to river at Zandvliet	CAS NTU, link to LRVs claimed. To achieve LRVs of 0.5 for viruses, 0.5 for <i>Cryptosporidium</i> , and 0.5 for <i>Giardia</i> . <i>Campylobacter</i>
	Nitrate	mg/ℓ	<5.0	8.0	>10.0		
	Ammonium	mg/ℓ	<1.5	1.7	>2.0		
	EC	mS/m	<100	125	>150		
CCP-3: Zandvliet BNR	Turbidity	NTU	<0.3	0.5	>1.0	take cell offline and investigate	NTU, link to LRVs claimed To achieve LRVs of 1.0 for viruses, 1.5 for <i>Cryptosporidium</i> , and 1.5 for <i>Giardia</i> , <i>Campylobacter</i>
			<0.3	0.5	>1.0	Discharge to river	
	Nitrate	mg/ℓ	<5.0	6.5	>8.0	Discharge to river	
CCP-4: Faure NWS Ozonation	Ozone CT	mg-min/ℓ	>3.3	3.0	<2.0	Failure of Ozone system: Water not taken to BAC, discharge to river	To achieve LRVs of 4 for viruses, and 4 for <i>Giardia</i> , <i>Campylobacter</i>
	[O ₃] for each reactor: Reactor #1, Reactor #2, Reactor #3	mg/ℓ	>0.3	0.25	<0.2		
	[O ₃] overall	mg/ℓ	>0.3	0.25	<0.2		
CCP-5: Faure NWS BAC filtration	Total Organic Carbon (TOC)	mg/ℓ	<6.0	7.0	>8.0	Failure of BAC filter: take offline and investigate	No LRV claimed
	UV-254	cm ⁻¹	TBD	TBD	TBD	Failure of BAC system: Isolate feed to GAC and discharge to river	
CCP-6: Faure NWS GAC filtration	TOC	mg/ℓ	<5.0	6.0	>7.0	Failure of GAC filter: take filter offline and investigate	No LRV claimed
	UV-254	cm ⁻¹	TBD	TBD	TBD	Failure of GAC system: discharge to river after UV AOP process/investigate rerouting	
CCP-7: Faure NWS Ultrafiltration	Turbidity – skids	NTU	<0.10	0.15	>0.15	Failure of UF skid: take offline for MIT, Failure of UF system: discharge to river after UV AOP process/investigate rerouting	To achieve LRVs of 4 for <i>Cryptosporidium</i> , and 4 for <i>Giardia</i> , <i>Campylobacter</i>
	Turbidity - system	NTU	<0.10	0.15	>0.15		
	UF Membrane Integrity Test (MIT): Diff pressure decay	kPa/min	TBD	TBD	TBD		
CCP-8: Faure NWS UV AOP	UV dose	mJ/cm ²	650	600	550	Discharge to river/investigate rerouting	To achieve LRVs of 6 for viruses, <i>Cryptosporidium</i> , and <i>Giardia</i> , <i>Campylobacter</i>
	H ₂ O ₂ dose	mg/ℓ	12	10	8		
CCP-9: Faure NWS Chlorination	Chlorination CT	mg-min/ℓ	4.5	3.6	3.0	Water not taken to Faure WTP, discharge to river/investigate rerouting	To achieve LRVs of 2 for viruses, <i>Campylobacter</i>
	Chlorine concentration	mg/ℓ	0.5	0.4	0.33		
CCP-10: Blending ratio with surface water into Faure WTP	Reclaimed water flowrate, F1	m ³ /hour	20%: 70 Mℓ/d	</> 20% for more than 15 mins		Lower reclaimed water flowrate or increase source water flowrate	No LRV claimed
	Surface water flowrate, F2	m ³ /hour	80%: 280 Mℓ/d				

Please note that these parameters are as currently proposed by the CoCT Project Team and are subject to confirmation during process commissioning and validation.

TABLE 3: PROPOSED ONLINE & ROUTINE COP MONITORING PARAMETERS, WITH ACTIONS TO BE TAKEN IF TARGETS ARE NOT MET

COP	Parameter	Unit	Online/Routine sampling	Target range*	Action*
COP-0: Raw sewage inlet into Zandvliet	pH	-	Online	TBC	Operational adjustments at Zandvliet
	EC	mS/m	Online	TBC	Operational adjustments at Zandvliet
	COD	mg/ℓ	Routine	TBC	Operational adjustments at Zandvliet
	TKN	mg/ℓ	Routine	TBC	Operational adjustments at Zandvliet
	NH ₄	mg/ℓ	Routine	TBC	Operational adjustments at Zandvliet
	TSS	mg/ℓ	Routine	TBC	Operational adjustments at Zandvliet
COP-1 at CCP-1	COD	mg/ℓ	Routine	TBC	Operational adjustments at Faure NWS
COP-2 at CCP-2	COD	mg/ℓ	Routine	TBC	Operational adjustments at Zandvliet BNR bypass Primary Settling Tanks to increase organic load
COP-3 at CCP-3	COD	mg/ℓ	Routine	TBC	Operational adjustments at Faure NWS
COP-10: Combined Zandvliet Feed to Faure NWS	% removal of DOC		Routine	TBC	Operational adjustments at Faure NWS
	EC	mS/m	Online	TBC	Operational adjustments at Faure NWS
	Turbidity	NTU	Online	TBC	Operational adjustments at Faure NWS
	UV ²⁵⁴	cm ⁻¹	Online	TBC	Operational adjustments at Faure NWS
	Microbiological indicators	#/100 mℓ	Routine	TBC	Operational adjustments at Faure NWS
COP-4 at CCP-4	Turbidity	NTU	Online	TBC	Operational adjustments at Faure NWS
	Oxidation-Reduction Potential (ORP)	mV	Online	TBC	Operational adjustments at Faure NWS
	DOC	mg/ℓ	Routine	TBC	Operational adjustments at Faure NWS
COP-5 at CCP-5	BAC Filter Turbidity	NTU	Online	TBC	take filter offline and investigate
	BAC System Turbidity	NTU	Online	TBC	TBC
	DOC	mg/ℓ	Routine	TBC	TBC
COP-6 at CCP-6	GAC Filter Turbidity	NTU	Online	TBC	take filter offline and investigate
	GAC System Turbidity	NTU	Online	TBC	TBC
	UV-254	cm ⁻¹	Online	TBC	TBC
	DOC	mg/ℓ	Routine	TBC	TBC
COP-7 at CCP-7	UV-254	cm ⁻¹	Online	TBC	TBC
	DOC	mg/ℓ	Routine	TBC	take filter offline and investigate
COP-8 at CCP-8	UV-254	cm ⁻¹	Online	TBC	TBC
	Turbidity	NTU	Online	TBC	TBC
	DOC	mg/ℓ	Routine	TBC	TBC
	Microbiological indicators	#/100 mℓ	Routine	TBC	TBC
COP-9 at CCP-9	pH	-	Online	TBC	TBC
	EC	mg/ℓ	Online	TBC	TBC
	TOC	mg/ℓ	Online	TBC	TBC
	Nitrate	mg/ℓ	Online	TBC	TBC
	Ammonia	mg/ℓ	Online	TBC	TBC
	Turbidity	NTU	Online	TBC	TBC
	ORP	mV	Online	TBC	TBC
	Microbiological indicators	#/100 mℓ	Online	TBC	TBC
COP-11: Inlet from Source Water Dams	% removal of DOC		Online	TBC	TBC
	pH	-	Online TBC	TBC	TBC
	EC	mS/m	Online TBC	TBC	TBC
	TOC	mg/ℓ	Online TBC	TBC	TBC
	Nitrate	mg/ℓ	Online TBC	TBC	TBC
	Turbidity	NTU	Online	TBC	TBC
	UV ²⁵⁴	cm ⁻¹	Online	TBC	TBC
	Microbiological indicators	#/100 mℓ	Routine	TBC	TBC
COP-12: Stabilisation of outflow from Faure NWS	Langelier Saturation Index	-	Online	>0	TBC
	Calcium-Carbonate Precipitation Potential	mg/ℓ	Online	-3	TBC

* Limit values, as well as frequencies of routine monitoring, and intervention actions, to be confirmed (TBC) during process commissioning and validation.

The IAP recommends that clear and unambiguous protocols be developed, tested, and optimised for all deviations of CCP “alert” and “action” limits, as well as how to handle streams that do not meet these limits. For example, while the current protocol entails diverting all water at the end of any barrier in the AWTP that does not meet the “action” CCP back to the river, the IAP is of the opinion that this protocol can be enhanced, considering that treatment at each barrier involves the addition of expensive chemicals and energy. It may therefore be more efficient from a water conservation perspective, as well as more energy efficient and cost effective to, instead of diverting water to the river that does not meet the “action” levels at CCP-6 and onward, rather divert water that does not meet the “alert” levels at CCP-6 and onward back to the inlet of the AWTP. Nutrient recovery options could also be considered.

In respect of the COP monitoring parameters, as captured in Table 3 on page 18, it is noteworthy that the measurement of pH and Electrical Conductivity (EC) in wastewater arriving at the inlet to the Zandvliet WWTW (COP-1) will give an early warning to operators of the WWTW and to Source Control employees of “unusual” or possibly illegal discharges entering the plant. EC serves as a specific indicator for intrusion into the network, and operational protocols for the Zandvliet WWTW should specify the maximum allowed % increase for the incoming EC into the Zandvliet WWTW (as measured at COP-1). An operational protocol should also be developed and implemented with regard to the measurement of the % removal of Chemical Oxygen Demand (COD), DOC, UV²⁵⁴, NH₄, Total Kjeldhal Nitrogen (TKN) and Microorganisms at both the Zandvliet WWTW and the Faure AWTP.

With regard to routine monitoring, the IAP recommends that regular and ongoing composite sampling of the incoming effluent into the Zandvliet WWTW should be undertaken. These samples should be analysed chemically for both the regular inorganic parameters, as well as for organic parameters on the list of surrogates that has been developed based on the QCRA for the upstream effluent and the final treated effluent from Zandvliet. In the event that any irregularities in the chemical composition of these samples are observed, the monitoring for CECs in the reclaimed water produced by the AWTP should be intensified, and the list of surrogate CECs be reviewed accordingly. Similarly, these composite samples should be analysed to determine the presence of microbiological organisms, and should any deviations be observed from the organisms identified in the QCRA for the upstream effluent and the final treated effluent from Zandvliet, the monitoring for indicator organisms in the reclaimed water produced by the AWTP should be intensified, and the list of indicator organisms reviewed.

The IAP is of the opinion that, if the HACCP and operational protocols are being followed, the CCP and COP limit values are adhered to, and the assumptions discussed above be addressed, and water that does not meet the limit values is not treated for domestic use purposes but discharged to a river or diverted back into the treatment process, there will be no need for an Engineered Storage Buffer Tank, and that the AWTP at the Faure NWS will be able to supply water to the Faure WTP on an ongoing basis to facilitate the production of water of a suitable quality for domestic for the CoCT. This is however based on the additional assumption that the blend of natural source water and reclaimed water can be maintained at a fixed ratio, especially when there are problems with the natural water source supply.

The IAP notes that online monitoring sensors at both the CCPs and COPs would require validation and regular maintenance, for which budgetary provision should be made, and responsibilities assigned. The Decision Support System that is currently being developed for the City is critical in ensuring the capture and flow of information between different sections and departments of the CoCT, and mechanisms are to be established to ensure that incoming data, especially data relating to deviations of CCPs, are flagged into actionable tasks with associated responsibilities where appropriate. Also refer to the discussion regarding **Institutional Arrangements** on page 21 below.

Regulatory Aspects

There are quite a number of regulatory aspects associated with a project such as the Faure NWS, however, the scope of work of the IAP did not include the determination of compliance with regulatory aspects, rather to determine if there are any regulatory gaps that may have been overlooked, or that require specific attention.

During the deliberations of the IAP and interactions with the project team of the CoCT, the current status of and progress with regulatory requirements under the *National Environmental Management Act 107 of 1998* (NEMA); *National Water Act 36 of 1998* (NWA), *Promotion of Administrative Justice Act 3 of 2000* (PAJA), *Local Government Municipal Structures Act 117 of 1998*, amongst others, and relevant regulations had been discussed. In particular, in order to address constitutional obligations in respect of transparency and accountability, the discussions between the IAP, City officials, and the CoCT project team, led to the development of a revised communication strategy that facilitates dialogue and interaction, as discussed in the section on **Communication below**. The IAP is of the opinion that the project team and legal advisors of the CoCT have their responsibilities under control in terms of the relevant legal requirements and are well advanced in the process of obtaining authorisations and addressing potential future legal requirements, including requirements relating to the registration of qualified operators¹³ and establishing relevant servitudes, where necessary.

The success of urban water reclamation projects is dependent on both political will and support from provincial and national government. The one gap that has been identified relates to the lack of any regulatory requirements in the current national statutory environment controlling water reclamation. With the Faure NWS project, the first project of this scale in South Africa, the CoCT is in fact establishing a benchmark for the country, that may very well be used for the preparation of future regulations relating to water reuse.

Currently, the NWA does not contain a definition for concepts such as “water reuse”, “water reclamation”, or even “treated wastewater”, and these are gaps that could lead to conundrums in legal interpretation disputes. In addition, the SANS 241 Drinking Water Standard does not currently make provision for CECs and LRVs, as discussed on page 10, and there is currently no regulatory prescription for methodologies to be followed for aspects such as upstream source characterisation, QCRA, QMRA, establishment of HACCP and CCP targets, establishment of LRV targets for pathogen removal in the treatment of wastewater for domestic reuse, etc.

The IAP therefore recommends that the CoCT, in collaboration with the WRC, engages the national regulator, the DWS, to prepare a regulation for water reclamation schemes throughout the country, utilising international best practice and the HACCP methodology, based on the work done and lessons learned in this project, as a proactive stance to ensure the protection of public health and provide clarity and certainty for a future regulatory environment. This would prevent a situation where the national regulator creates a regulation for such reclamation schemes at some point in future that differs substantially from the approaches followed for the Faure NWS, which could pose a risk that the Faure NWS would require significant changes to meet the requirements of an unknown regulation. In addition, the IAP recommends that the work done on this project, together with the work previously done by the DWS, the WRC, and other institutions, as well as domestic reuse rules developed collaboratively with regulators in other countries with water reclamation schemes (e.g. USA (Colorado, Arizona, Texas) and Australia (Queensland)), be consolidated into a Best Practice Guideline for reclaimed water in South Africa.

With regard to the City’s own regulatory powers, it is recommended that the Wastewater and Industrial Effluent Bylaw of the City, which was published in 2013, be revised to make specific provision to control discharges of industrial effluent upstream from the Zandvliet WWTW. Such a revised Bylaw should be based on a clear industrial pollution control policy, with emphasis on upstream control. The revised Bylaw need to specify the required

¹³ **GN R. 3630** in GG 48865 of 30 June 2023. *Regulations for the Compulsory National Standards for Process Controller and Water Services Works*

measurement and reporting of critical components at identified industrial premises that has the potential to discharge effluents that could jeopardise the operation of both the Zandvliet WWTW and the Faure NWS, with cut-off valves and holding tanks where trigger values of these critical components are being exceeded. The revised Bylaw also need to be fair, unambiguous, and easily understandable to the industry, clearly identifying what is allowed and not allowed to enter the sewer, the types of effluent that would require diversion or on-site treatment before it could be accepted into the sewer, how and where effluents that cannot be accepted into the sewer need to be diverted to, the effluents that are required at the WWTW to ensure its proper operation (for example easily biodegradable COD-effluents that would allow denitrification).

Institutional Arrangements, Internal Liaison, and Oversight

The long term sustainable operation and maintenance of the Faure NWS depends as much on an optimal design, as on ensuring that the institutional arrangements that are in place to support and facilitate the implementation of such design. For example, assumptions for the design and successful operation of the Faure NWS include the availability of a number of chemicals, most importantly chlorine, ozone, and H_2O_2 , as well as the availability of consumables such as replacement filters, etc. This intrinsically relies on the capacity of the CoCTs Supply Chain Management section to timeously ensure the procurement and supply of these consumables. Furthermore, the IAP considers regular and open communication between those CoCT personnel responsible for Source Water Control, the operators of the Zandvliet WWTP, the Faure NWS and the Faure WTP, and Scientific Services as critical for the successful operation of the Faure NWS. In addition, the ability of the Scientific Services section to undertake water quality analysis for relevant parameters identified in source water would be critical for the successful operation of the Faure NWS. Most importantly, the successful operation of the Faure NWS is dependent on the people responsible for its operation, and therefore, knowledgeable process controllers who are trained in accordance with the relevant regulations have to be employed and retained, and the staff complement also have to meet these regulations. In particular, the availability of a limited pool of experienced operators is of concern, and the IAP recommends that this scarce skill should be developed, and operators retained, in collaboration with the national government and training institutions.

In addition, the IAP deems it pertinent that specific arrangements be made at the appropriate level in the management structures of the City to facilitate implementation oversight, both during the construction and the operation of the project, especially where subcontractors are involved. In this respect, it is recommended that occasional mock emergency exercises be undertaken to ensure that protocols are refined, and staff are well versed in the proper response to a range of potential issues with the source water, the scheme, exceedance of CCPs and COPs, etc. Such oversight will ensure regulatory accountability and secure financial investment, as well as successful management of contractors, change management, and succession planning. In this respect, the IAP is of the opinion that COPs should also be specified for (a) source water quality control as discussed in the section on water safety planning aspects; (b) supply chain management; and (c) availability of qualified operators, in addition to the COPs specified for the performance of the different treatment processes.

These aspects require institutional arrangements and regular liaison engagements between the key line functions of the CoCT, especially Supply Chain Management, Scientific Services, Pollution Control, Decision Support, Human Resources, and between the Bulk Water and Wastewater divisions, as well as with the Spatial Planning section of the City, and with those in the Legal and Procurement sections responsible for contract management. It is the opinion of the IAP that ongoing communication between these key line functions is essential, and the recommendation is that regular liaison engagements between these line functions be held on an ongoing basis, and not be regarded as an *ad hoc* exercise.

It is therefore the recommendation of the IAP that an Internal Liaison and Oversight Committee be established by the CoCT, to both ensure clear communication between the different responsible line functions, and to facilitate quick and responsive decision-making at the appropriate level. This Internal Liaison and Oversight Committee

should for example have decision-making power in respect of the verification and validation of online instrumentation used in the measurement of CCPs and COPs, changes in contracts, changes in operators and personnel, as well as the requirements for the qualifications and level of experience of contractors, operators, and personnel. In addition, this Internal Liaison and Oversight Committee should obtain all data and information, to evaluate and to decide on and recommend appropriate remedial actions to relevant authorities and stakeholders, including recommendations and decision trees and responsibilities to stop operations of the Faure NWS treatment if a risk arises that the reclaimed water will not meet with the required specifications.

One of the first tasks that this Committee should undertake, would entail the development of a “change management protocol”, to determine the changes in the barrier treatment system that can be regarded as “less critical”, “critical”, and “highly critical”. It is recommended that at least three (3) decision-making levels are to be established, for example “less critical” aspects for which decisions can be taken by the responsible operators on site; “critical” aspects, where decisions are to be taken by the Liaison and Oversight Committee, and “highly critical” aspects, where the ongoing IAP and political decision-makers are to be involved in taking the decision about a change to the system, and the public informed about such changes. This in itself would establish a “protection barrier” in the barrier treatment system.

The ongoing operation of the various components of the system, i.e., the Zandvliet WWTW, the Faure NWS AWTP, and the Faure WTP is totally dependent on the availability of electricity and the presence of qualified operators, and in this respect, the IAP recommends that the Zandvliet WWTW, the Faure NWS AWTP, the Faure WTP, and the Scientific Services laboratories be added to the “critical infrastructure” of the CoCT, so that these facilities are not affected by load-shedding or industrial action.

Lastly, it is outside the brief of the IAP to oversee the financial aspects associated with the implementation of the Faure NWS. However, based on the experience of the members of the IAP, large scale water projects such as this is often prone to undue financial influences and interests, which could jeopardise its successful implementation. In order to ensure the integrity of the project through the four pillars of water integrity (transparency, accountability, participation, and anti-corruption (“TAP-A”)), it is therefore recommended that an independent Water Integrity Assessment or Audit be undertaken in accordance with the protocols established by the Water Integrity Network to assess potential integrity issues that could place the project at risk.¹⁴

Communication: Awareness, Education, and Public Engagement

Acceptance of the water produced by the Faure NWS, and the willingness to pay for the water produced by the Faure NWS, will depend to a large extent on whether the public trusts the CoCT to design, operate, finance, manage and govern the Faure NWS in such a manner that the water produced will be beneficial to its users, and perceives the water to be suitable for human consumption. An institution earns the trust of the public through its actions, and through the transparency and openness with which it communicates its actions, successes, and failures, to the public. International and local research indicated that knowledge is the overarching driver that consistently correlates with public perception and acceptance of the use of reclaimed water.¹⁵

¹⁴ The Water Integrity Network, with support from the United Nations, has some excellent resources available to facilitate ensuring integrity in big water projects. For details, see for example <https://www.waterintegritynetwork.net/post/integrity-assessment-tool> and <https://www.waterintegritynetwork.net/post/framework-for-integrity-in-infrastructure-planning-fiip>

¹⁵ The findings of recent surveys of the WRC and the CoCT raised concerns about the South African public’s knowledge, awareness, perception, and trust as they relate to the use of reclaimed water as an alternative water supply source.

Effective communication in respect of the Faure NWS is therefore essential for its successful implementation, and such communication should be accessible and transparent, and should include both contextual awareness and education regarding the reclamation of water for domestic use;¹⁶ as well as two-way public engagement processes that seek the input of the public and involve them in decision-making by providing an opportunity to the public to make comments on the project, and in which the public receives responses on their comments.

It is therefore critical that the City's communication strategy and communication plans address all these aspects. During the engagement of the IAP with the CoCT officials responsible for communication the importance of these aspects was recognised, and during November 2023, the CoCT provided the IAP with a revised Public Engagement Strategy and Communication Action Plan which addresses most of the IAPs earlier comments in relation to public engagement and communication regarding the project.

In this respect, the CoCT has formulated an overall strategic objective for its communication regarding the Faure NWS, as follows: *"To inform, educate, consult, and collaborate with the public on the City's water strategy and water reuse programme in a scientific, effective and sustainable manner, in order to build trust and interactive relationships and to ensure effective long-term implementation of the Faure NWS"*.

On the basis of this overall strategic objective, which is supported by the IAP, the City formulated a Communication Strategy for the Faure NWS, the components of which is illustrated in **Figure 8 on page 24**. The IAP is of the opinion that an Overall Communication Strategy that addresses the aspects illustrated in Figure 8 can achieve the objective of the Strategy, and can result in informed and engaged citizens that supports efforts to secure sufficient water for the future, including the use of reclaimed water produced by the Faure NWS. Three aspects need to be highlighted in this respect:

- The terminology used in relation to the project and in respect of reclaimed water needs to be tested with a selected cross-cutting group of users, and then used consistently by all involved in the project.
- It is of specific importance that a dedicated component of the communication strategy focuses on raising awareness in the upstream catchment, alerting especially discharging industries that their effluents will now become "source water", and keeping these upstream industries informed of their performance with regular water quality reports.
- Where there appears to be community indifference to the seriousness of the water crisis, a specific effort should be made to raise awareness and build knowledge, which should include instilling a sense of pride in the quality of water supplied by the CoCT to its community, for example by highlighting achievement of LRV-targets and obtaining Blue Drop and Green Drop awards.

In this regard, ongoing education and capacity building efforts amongst both adults and school children are essential and should include innovation education programs. The IAP supports and commends the project team for the establishment of the education facilities at the Faure NWS and recommends that an education officer be appointed at the site.

Considering the above, the IAP recommends that the CoCT follows the same communication strategy for all its water-related communication. The specific content and messaging will differ for the various water sources and water projects, but the messaging and terminology used must be clear and consistent. The City, however, must demonstrate its capability to implement not only its communication strategy, but also its water strategy, as well as the Faure NWS, so that the public consistently receives water that is suitable for human consumption.

¹⁶ Contextual awareness includes a basic understanding of the natural and urban water cycle, the problems created by limited water resources, increasing consumerism, climate change, and why it is necessary to reclaim water; and education includes knowledge transfer on aspects such as the Water Strategy of the CoCT, how reclaimed water will help to ensure water security for the CoCT, what are the treatment processes used to ensure that the reclaimed water is safe to drink and will meet applicable drinking water standards, etc., which will change perceptions regarding reclaimed water and enable users to distinguish between fact and misconception.

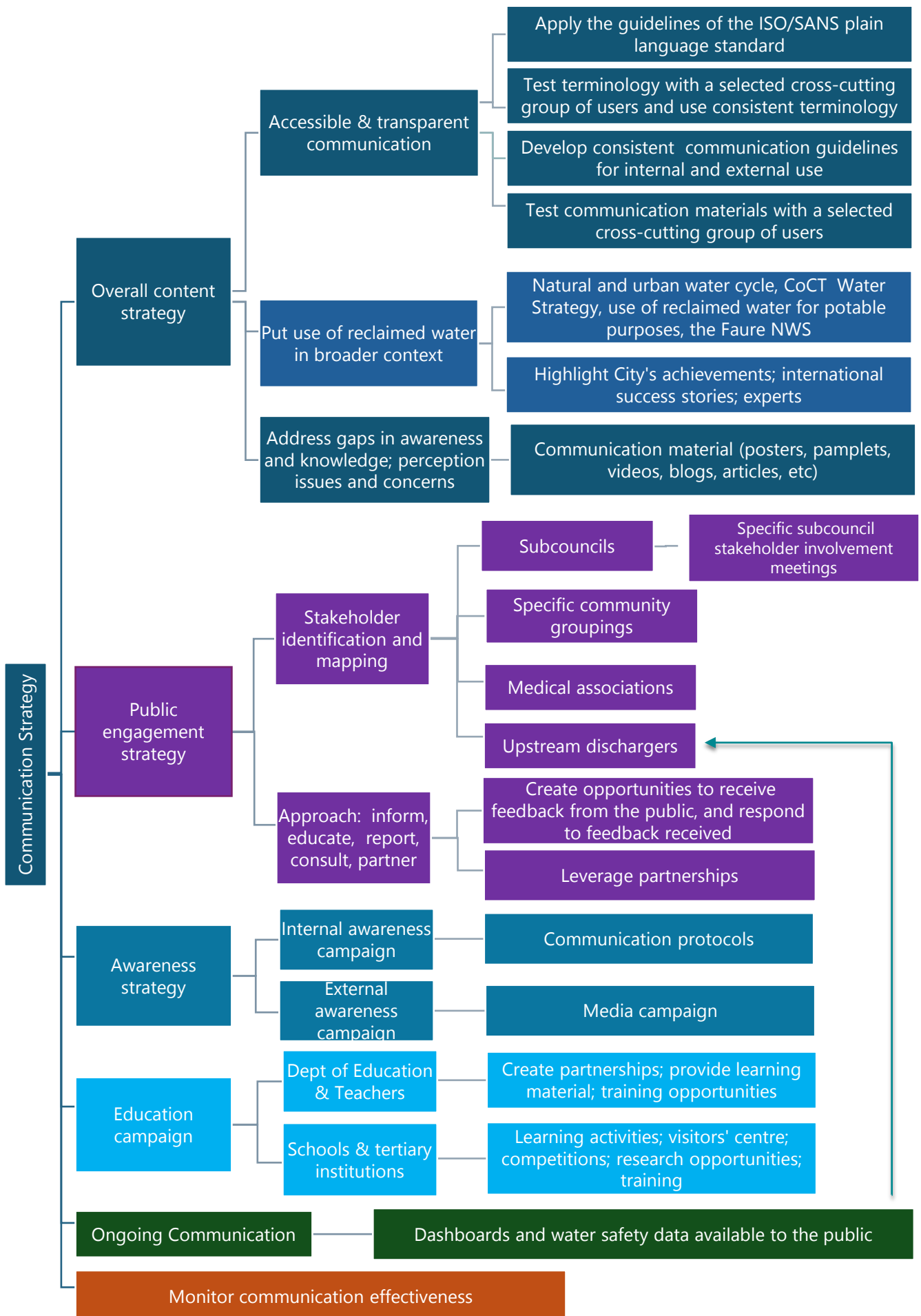


FIGURE 8: FAURE NWS COMMUNICATION STRATEGY OVERVIEW

Chapter 3: Recommendations & Conclusion

As indicated in Chapter 1, the members of the IAP were requested during their workshop held in December 2023 to give guidance regarding the implementation of the Faure NWS, and it was decided that the IAP would compile a report outlining the aspects associated with the implementation of the Faure NWS that are considered by the IAP as key and critical to ensure the successful implementation of the Faure NWS. Chapter 2 of this Report discussed these key and critical aspects that, in the opinion of the IAP, would ensure the successful implementation of the Faure NWS. This Chapter summarises the key recommendations of the IAP and draws an overall conclusion in this respect.

Recommendations

The aspects that are considered key and critical by the IAP, and the relevant recommendations of the IAP in respect of each aspect, can be summarised as follows:

- **Water and Sanitation Safety Planning:**
 - The assessment of potential sources of contamination from the industries in the catchment upstream of the Zandvliet WWTW requires further attention, specifically an updated map of upstream effluents, a catchment audit, and conducting a QCRA to characterise the potential risk posed by the effluents from individual industrial premises that discharge into the Zandvliet WWTW. This is necessary to identify the potential presence of the CECs mentioned above in incoming effluent streams.
 - The outcome of this upstream QCRA should indicate the type and nature (composition) of the upstream industrial effluents that are being discharged into the sewers that feed the Zandvliet WWTW from its upstream catchment, as well as an assessment of the risks posed by each of these upstream effluents, identifying interventions to manage these risks, and incorporating the identified risks into a regularly updated WSP.
 - On the basis of the outcome of the both the QCRA on the incoming streams and the QCRA on the final treated effluent from the Zandvliet WWTW, a list of indicator parameters should be developed that is specifically tailored to critical contaminants contained in the effluents of upstream industries that have the potential to jeopardise the operation of both the Zandvliet WWTW and the Faure NWS.
 - A monitoring programme specifically aimed at the measurement of these critical contaminants should be developed and implemented, including at identified industrial premises that has the potential to discharge effluents that could jeopardise the operation of both the Zandvliet WWTW and the Faure NWS.
 - Once the flows and significant chemical constituents of all industrial effluents have been confirmed, consideration should be given to the installation of on-line sensors at key nodal points in the sewer network to identify abnormal wastewater inflow events.
 - Pollution control intervention activities should include actions to prevent illegal discharges, such as the installation of cut-off valves and holding tanks where trigger values of these critical components are being exceeded, as well as the publication and implementation of a penalty system to impose a fine when expected or agreed values are exceeded.
 - Full financial and institutional support should be given to both the Scientific Services laboratories, who may need to develop methods to facilitate the analysis for specific contaminants that are identified in upstream industrial effluents (based on the outcome of the updated QCRA), and the Pollution Control section of the City, who need to prioritise pollution control intervention activities where non-compliances are identified that could adversely affect the operation of the Zandvliet WWTW and the Faure NWS.

- The implementation of these controls should be facilitated under a revised Wastewater and Industrial Effluent Bylaw, which should also make provision for the publication and implementation of a penalty system to impose a fine when expected or agreed trigger values are being exceeded.
- The Zandvliet WWTW should achieve and maintain a Green Drop status above 90% and a CCR of below 25% to be considered as a suitable source water for the Faure NWS.
- **Faure NWS: Design, Treatment Targets, and Measurement**
 - The IAP recommends that the ability of the existing stabilisation plant at the Faure WTP to also handle the stabilisation of the treated reclaimed water be investigated and verified.
 - To derive site-specific specifications for chemicals that could potentially be present in the treated effluent produced by the Zandvliet WWTW, and subsequently be contained in the reclaimed water produced by the Faure NWS, and that are not currently listed in SANS 241, the outcome of the QCRA's undertaken on both the Zandvliet final treated effluent and the incoming effluent into Zandvliet as discussed under the section dealing with **Water and Sanitation Safety** Planning should be used as basis to identify potential chemicals that could pose a health risk, and treatment targets should be developed for specific identified surrogate or indicator chemicals, to represent groups of the organic chemicals listed in **Annexure "D"**.
 - The IAP supports the LRVs derived for reference pathogens for the Faure NWS of 12.5 for Enteric norovirus, 11.5 for *Cryptosporidium*, 10 for *Giardia lamblia*, and 9 for *Campylobacter*, and recommends that the Faure NWS be designed and operated to meet these LRVs. This support is qualified, and is based on the understanding that the following assumptions are to be addressed:
 - that a revised QMRA is to be undertaken on the final treated effluent from Zandvliet following its upgrade, to confirm the appropriateness of the reference pathogens and LRV targets selected for the Faure NWS;
 - that ongoing water quality testing for identified reference pathogens be undertaken (which could include, in the medium term, a QMRA on the incoming effluents into the Zandvliet WWTW) to build a site-specific pathogen profile, against which claimed LRVs can be validated or revised targets specified where required;
 - that, where relevant, the design of the treatment processes should be upgraded to meet such revised targets prior to the finalisation of the design for construction; and
 - that, during the testing phase of the Faure NWS, possible operational diversions are substantiated, the assumptions made in the development of the LRVs relating to the operation of the Faure NWS in accordance with HACCPs and the ongoing monitoring of the identified CCPs and COPs are verified, that the LRV credits claimed for especially the CAS and MBR at the Zandvliet WWTW are validated, and appropriately adjusted when operational conditions indicate that assumptions were not valid or sufficiently precautionary, or that LRVs claimed are not being met;
 - The IAP supports the location of and parameters to be tested for at the proposed CCPs, on the basis of the assumption that the recommendations of this report in respect of monitoring are to be implemented where relevant.
 - The IAP recommends that clear and unambiguous protocols be developed, tested, and optimised for all deviations of CCP "alert" and "action" limits, as well as how to handle streams that do not meet these limits.
 - While the current protocol entails diverting all water at the end of any barrier in the AWTP that does not meet the "action" CCP back to the river, the IAP is of the opinion that this protocol can be enhanced, considering that treatment at each barrier involves the addition of expensive chemicals and energy. It may therefore be more efficient from a water conservation perspective, as well as more energy efficient and cost effective to, instead of diverting water that does not meet the "action"

levels at CCP-6 and onward to the river, rather divert water that does not meet the “alert” levels at CCP-6 and onward back to the inlet of the AWTP. Nutrient recovery options could also be considered.

- In respect of the COP monitoring parameters, as captured in Table 3 on page 18, it is noteworthy that the measurement of pH and Electrical Conductivity (EC) in wastewater arriving at the inlet to the Zandvliet WWTW (COP-1) will give an early warning to operators of the WWTW and to Source Control employees of “unusual” or possibly illegal discharges entering the plant. EC serves as a specific indicator for intrusion into the network, and operational protocols for the Zandvliet WWTW should specify the maximum allowed % increase for the incoming EC into the Zandvliet WWTW (as measured at COP-1).
- An operational protocol should also be developed and implemented with regard to the measurement of the % removal of Chemical Oxygen Demand (COD), DOC, UV²⁵⁴, NH₄, Total Kjeldhal Nitrogen (TKN) and Microorganisms at both the Zandvliet WWTW and the Faure AWTP.
- With regard to routine monitoring, the IAP recommends that regular and ongoing composite sampling of the incoming effluent into the Zandvliet WWTW should be undertaken. These samples should be analysed chemically for both the regular inorganic parameters, as well as for organic parameters on the list of surrogates that has been developed based on the QCRA for the upstream effluent and the final treated effluent from Zandvliet. In the event that any irregularities in the chemical composition of these samples are observed, the monitoring for CECs in the reclaimed water produced by the AWTP should be intensified, and the list of surrogate CECs be reviewed accordingly.
- Similarly, these composite samples should be analysed to determine the presence of microbiological organisms and should any deviations from the organisms identified in the QCRA for the upstream effluent and the final treated effluent from Zandvliet be observed, the monitoring for indicator organisms in the reclaimed water produced by the AWTP should be intensified, and the list of indicator organisms reviewed.
- The IAP is of the opinion that, if the HACCP protocols are being followed, the CCP and COP limit values are adhered to and the assumptions discussed above be addressed, and water that does not meet the limit values is not treated for domestic use purposes but discharged to a river or diverted to the feed reservoir to restart the treatment process, there will be no need for an Engineered Storage Buffer Tank, and that the Faure NWS will be able to deliver water of domestic quality via the Faure WTP on an ongoing basis. This is however based on the assumption that the blend of natural source water and reclaimed water can be maintained at a fixed ratio, especially when there are problems with the natural water source supply.
- The IAP notes that online monitoring sensors at both the CCPs and COPs would require validation and regular maintenance, for which budgetary provision should be made, and responsibilities assigned.
- In this respect, the Decision Support System that is currently being developed for the City is critical in ensuring the capture and flow of information between different sections and departments of the CoCT, and mechanisms are to be established to ensure that incoming data, especially data relating to deviations of CCPs, are flagged into actionable tasks with associated responsibilities where appropriate.
- It is the recommendation of the IAP that COPs and operational protocols should also be specified for (a) source water quality control as discussed in the paragraph on water safety planning aspects; (b) supply chain management; and (c) operators, in addition to the CCPs and COPs specified for the performance of the different treatment processes.

- **Regulatory Aspects:**

- The IAP is of the opinion that the project team and legal advisors of the CoCT have their responsibilities under control in terms of the relevant legal requirements and are well advanced in the process of obtaining authorisations and addressing potential future legal requirements, including

requirements relating to the registration of qualified operators and establishing relevant servitudes, where necessary.

- The IAP recommends that the CoCT, in collaboration with the WRC, engages the national regulator, the DWS, to prepare a regulation based on the work done for and lessons learned in this project to regulate water reclamation schemes throughout the country.
- With regard to the City's own regulatory powers, it is recommended that the Wastewater and Industrial Effluent Bylaw of the City, which was published in 2013, be revised to make specific provision to control discharges of industrial effluent upstream from the Zandvliet WWTW. Such a revised Bylaw should be based on a clear industrial pollution control policy, with emphasis on upstream control. The revised Bylaw need to specify the required measurement and reporting of critical components at identified industrial premises that has the potential to discharge effluents that could jeopardise the operation of both the Zandvliet WWTW and the Faure NWS, with cut-off valves and holding tanks where trigger values of these critical components are being exceeded. The revised Bylaw also need to be fair, unambiguous, and easily understandable to the industry, clearly identifying what is allowed and not allowed to enter the sewer, the types of effluent that would require diversion or on-site treatment before it could be accepted into the sewer, how and where effluents that cannot be accepted into the sewer need to be diverted to, the effluents that are required at the WWTW to ensure its proper operation (for example easily biodegradable COD-effluents that would allow denitrification).

- **Institutional Arrangements:**

- The IAP considers regular and open communication between the CoCT personnel responsible for Source Water control, the operators of the Zandvliet WWTP, the Faure NWS, the Faure WTP, and Scientific Services as critical for the successful operation of the Faure NWS.
- The availability of a limited pool of experienced operators is of concern, and the IAP recommends that this scarce skill should be developed, and operators retained, in collaboration with the national government and training institutions.
- The IAP deems it pertinent that specific arrangements be made at the appropriate level in the management structures of the City to facilitate implementation oversight, both during the construction and the operation of the project, especially where subcontractors are involved. In this respect, it is recommended that occasional mock emergency exercises be undertaken to ensure that protocols are refined, and staff are well versed in the proper response to a range of potential issues with the source water, the scheme, exceedance of CCPs and COPs, etc.
- The IAP recommends that institutional arrangements and regular liaison engagements between the key line functions of the CoCT, especially Supply Chain Management, Scientific Services, Pollution Control, Decision Support, Human Resources, and between the Bulk Water and Wastewater divisions, as well as with the Spatial Planning section of the City, and with those in the Legal and Procurement sections responsible for contract management be held on a regular and ongoing basis, and not be regarded as an *ad hoc* exercise.
- It is therefore the recommendation of the IAP that an Internal Liaison and Oversight Committee be established by the CoCT, to both ensure clear communication between the different responsible line functions, and to facilitate quick and responsive decision-making at the appropriate level. This Internal Liaison and Oversight Committee should for example have decision-making power in respect of the verification and validation of online instrumentation used in the measurement of CCPs, changes in contracts, changes in operators and personnel, as well as the requirements for the qualifications and level of experience of contractors, operators, and personnel.
- In addition, this Internal Liaison and Oversight Committee should obtain all data and information, to evaluate and to decide on and recommend appropriate remedial actions to relevant authorities and stakeholders, including recommendations and decision trees and responsibilities to stop operations

of the Faure NWS treatment if a risk arises that the reclaimed water will not meet with the required specifications.

- One of the first tasks of this internal liaison committee would be the development of a “change management protocol”, to determine the changes in the barrier treatment system that can be regarded as “less critical”, “critical”, and “highly critical”. It is recommended that at least three (3) decision-making levels are to be established, for example “less critical” aspects for which decisions can be taken by the responsible operators on site; “critical” aspects, where decisions are to be taken by the Liaison and Oversight Committee, and “highly critical” aspects, where the ongoing IAP and political decision-makers are to be involved in taking the decision about a change to the system, and the public informed about such changes. This in itself would establish a “protection barrier” in the barrier treatment system.
- The IAP strongly recommends that the Zandvliet WWTW, the Faure NWS AWTP, the Faure WTP, and the Scientific Services laboratories be added to the “critical infrastructure” of the CoCT, so that these facilities are not affected by load-shedding or industrial action.
- In order to ensure the integrity of the project through the four pillars of water integrity (transparency, accountability, participation, and anti-corruption), the IAP recommends that an independent Water Integrity Assessment or Audit be undertaken in accordance with the protocols established by the Water Integrity Network to assess potential integrity issues that could place the project at risk.

- **Public Communication Strategy**

- The IAP is of the opinion that effective communication in respect of the Faure NWS is essential for its successful implementation. Such communication should be accessible and transparent, and should include both contextual awareness raising and education regarding the reclamation of water for domestic use; as well as two-way public engagement processes that take the input of the public seriously, and that involve them in decision-making, by providing an opportunity to the public to make comments on the project, and in which the public receives responses on their comments.
- The IAP is of the opinion that an Overall Communication Strategy that addresses the aspects illustrated in Figure 8 on page 24 can achieve the objective of the Strategy, and can result in an informed and engaged citizenry that supports efforts to secure sufficient water for the future, including the use of reclaimed water produced by the Faure NWS. Three aspects need to be highlighted in this respect:
 - The terminology used in relation to the project and in respect of reclaimed water needs to be tested with a selected cross-cutting group of users, and then used consistently by all involved in the project.
 - It is of specific importance that a dedicated component of the communication strategy focuses on raising awareness in the upstream catchment, alerting especially discharging industries that their effluents will now become “source water”, and keeping these upstream industries informed of their performance with regular water quality reports.
 - Where there appears to be community apathy and lack of appreciation for the seriousness of the water crisis, a specific effort should be made to raise awareness, which should include instilling a sense of pride in the quality of water supplied by the CoCT to its community, for example by highlighting achievement of LRV-targets and obtaining Blue Drop and Green Drop awards.
- In this regard, ongoing education and capacity building efforts amongst both adults and school children are essential and should include innovation education programs.
- The IAP supports and commends the project team for the establishment of the education facilities at the Faure NWS and recommends that an education officer be appointed at the site.
- The IAP recommends that the City follows the same communication strategy for all its water-related communication. The specific content and messaging will differ for the various water sources and

water projects, but the messaging and terminology used must be clear and consistent. The City, however, must demonstrate its capability to implement not only its communication strategy, but also its water strategy, as well as the Faure NWS, in such a manner that the public consistently receives water that is suitable for human consumption.

Conclusion

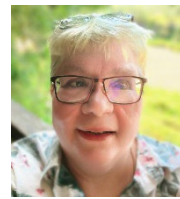
In conclusion, it is the expert opinion of the IAP that the CoCT has the capacity and ability to successfully implement, manage, and oversee the implementation and operation of the Faure NWS, provided that it is constructed and operated in accordance with the proposed design, and that the above recommendations are given serious and earnest consideration by the CoCT and its project team.

It is trusted that the findings and recommendations of the IAP as contained in this Report will contribute to the successful implementation and sustainable future operation of the Faure NWS.

For any questions regarding the content of the Report, please contact the chair of the IAP, Mr Ian Law, at iblaw@bigpond.com, or the WRC division responsible for research on reclaimed water.

Annexure A: Members of the IAP and their Areas of Expertise in relation to the Faure NWS

TABLE 4: SHORT BIOGRAPHIES OF THE MEMBERS OF THE IAP

Panellist	Qualification	Abbreviated Bio	Photo
Ian Law	MSc (Public Health Engineering)	Ian has more than 40 years of experience in advanced reuse projects in Southern Africa, Brazil, Canada, S E Asia, New Zealand, Australia and the US. He is a Fellow of the Singapore Water academy, and he (i) designed and commissioned Australia's first domestic non-potable reuse scheme at Rouse Hill in Sydney in 1994, (ii) designed and commissioned Singapore's NEWater scheme in 2000 – with the reclaimed water being introduced into the island's water supply as well as to hi-tech computer industries, (iii) was appointed by Singapore's national water agency (PUB) in 2014 to carry out 6- monthly audits of the island republic's water supply portfolio, and (iv) conducted an independent review of the design of Perth's drinking water recycling scheme in 2012.	
Bettina Genthe	MSc (Microbiology)	Independent senior researcher with 38 years' experience in CSIR's Water Resources group. Her area of specialisation includes water and health-related issues including environmental epidemiology, drinking water treatment, waste-water reuse, water pollution microbiology and health risk assessments (both chemical and microbiological human health risk assessments). She has specifically researched water related health issues linked to CECs	
Carin Bosman	MSc (Environmental Management and Geography), BSc (Hons) Chemistry	A leading water resources scientist and specialist in environmental, water resource and waste management and governance in South Africa, and a Senior Fellow of the Water Institute of South Africa (WISA). She has 35 years of experience in all aspects of water governance, ranging from organic chemical method development to ensuring public engagement at hazardous landfill sites. After her tenure of almost 20 years at the Department of Water and Sanitation (DWS), where her last position was Director: Resource Protection and Waste Management, she started her own consultancy, which focuses on advisory services, training, and digitised monitoring data solutions to ensure scientific integrity in decision-making.	
Dr Esper Ncube	PhD (Public Health), MSc (Water Utilisation), BSc (Hons) Chemistry	Dr Ncube has 33 years of work experience and is currently employed by Rand Water as Manager Process Technology, where she is accountable for the selection of best fit technologies for water treatment, process investigation and optimisation. She has held various Management positions in the National DWS and Rand Water since 1997, and is currently serving on the Water Reuse Subdivision of WISA, and is a Senior Fellow of WISA.	
Prof Frederic Leusch	PhD (Environmental Toxicology)	Professor in the School of Environment and Science at Griffith University (Australia), where he teaches biology and environmental toxicology. He also leads the Toxicology Research Group at the Australian Rivers Institute on the Gold Coast, which focuses on assessing the impact of environmental contaminants on humans and aquatic ecosystems. His current research focusses on endocrine disruption and the development and validation of new methods for exposure and hazard assessment. He serves on various national and international committees on issues relating to trace organic pollutants and drinking and recycled water quality.	

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Panellist	Qualification	Abbreviated Bio	Photo
Jürgen Menge	BSc (Microbiology)	He is a Senior Fellow of WISA, and currently works as a private consultant in water quality aspects. He was previously employed for 35 years by the City of Windhoek at its Gammams Laboratory, where he was involved in the design, tender evaluation, implementation, start up and operation of two Gammams WWTWs in Windhoek, as well as upgrades and extensions of the Goreangab water reclamation system. He developed the design parameters to test the feasibility of treatment unit upgrades.	
Associate Prof Kevin Winter	PhD (Environmental Management)	Currently employed as a senior lecturer in Environmental and Geographical Science at the University of Cape Town, and is a lead researcher at the University's Future Water Institute, focussing on surface water resource management, water quality, and urban waterways. He was also an active member of the CoCTs Water Resilience Task Team, and is currently serving on the City's Water Quality in Wetlands and Waterways Advisory Committee.	
Megan Schalkwyk	BSc.Eng. (Chemical Engineering)	Initially worked as a consultant in the water and wastewater sector, and is currently a Process Engineer at Umgeni Water, where she leads research and implements strategic initiatives for wastewater reclamation and water reuse, including conventional reuse technology, and biotechnology reuse solutions.	
Dr Sarah Slabbert	PhD (Sociolinguistics)	Specialises in development communication and has worked for the past 16 years in the water sector in communication and education, conducting research on how ordinary South Africans make sense of complex information. She established the Plain Language Institute to assist organisations to improve the quality of their interactions with customers and stakeholders through training and advisory services. She received the Knowledge Tree Award from the WRC for her work on informing policy and decision-making making use of Plain Language.	
Troy Walker	B.Eng (Chemical Engineering)	Has more than 30 years of experience in water treatment, especially in the field of membrane water treatment applications, conducting process design and commissioning of microfiltration technology to drinking water, wastewater, and water reuse projects. Undertaken ground-breaking work in the validation of membrane systems and the impact of industrial fouling chemicals on membrane performance in applying the Hazard Analysis and Critical Control Point (HACCP), which proved its success in the food industry, in water treatment applications.	
Dr James Crook	PhD (Environmental Engineering)	Is an internationally recognised expert in water reclamation and reuse, with more than 50 years of experience in developing engineering services for water and wastewater in the USA.	

TABLE 5: AREAS OF EXPERTISE OF IAP MEMBERS IN RELATION TO THE FAURE NWS

Panellist	Nationality	Plant Planning and Design	Construction and Operation of water reuse	Water Safety Planning	Water Quality and Public Health	Potable Reuse	Public Engagement	Other
Ian Law	Australia	✓	✓	✓	✓	✓	✓	
Bettina Genthe	South Africa			✓	✓	✓		
Carin Bosman	South Africa			✓	✓	✓	✓	✓
Dr Esper Ncube	South Africa	✓	✓	✓	✓	✓		
Prof Frederic Leusch	Australia			✓	✓	✓		
Jürgen Menge	Namibia	✓	✓	✓	✓	✓	✓	✓
Associate Prof Kevin Winter	South Africa				✓		✓	✓
Megan Schalkwyk	South Africa		✓		✓	✓		✓
Dr Sarah Slabbert	South Africa						✓	
Troy Walker	USA	✓	✓	✓	✓	✓		
Dr James Crook	USA	✓	✓	✓	✓	✓	✓	

Annexure B: List of documents reviewed by the IAP

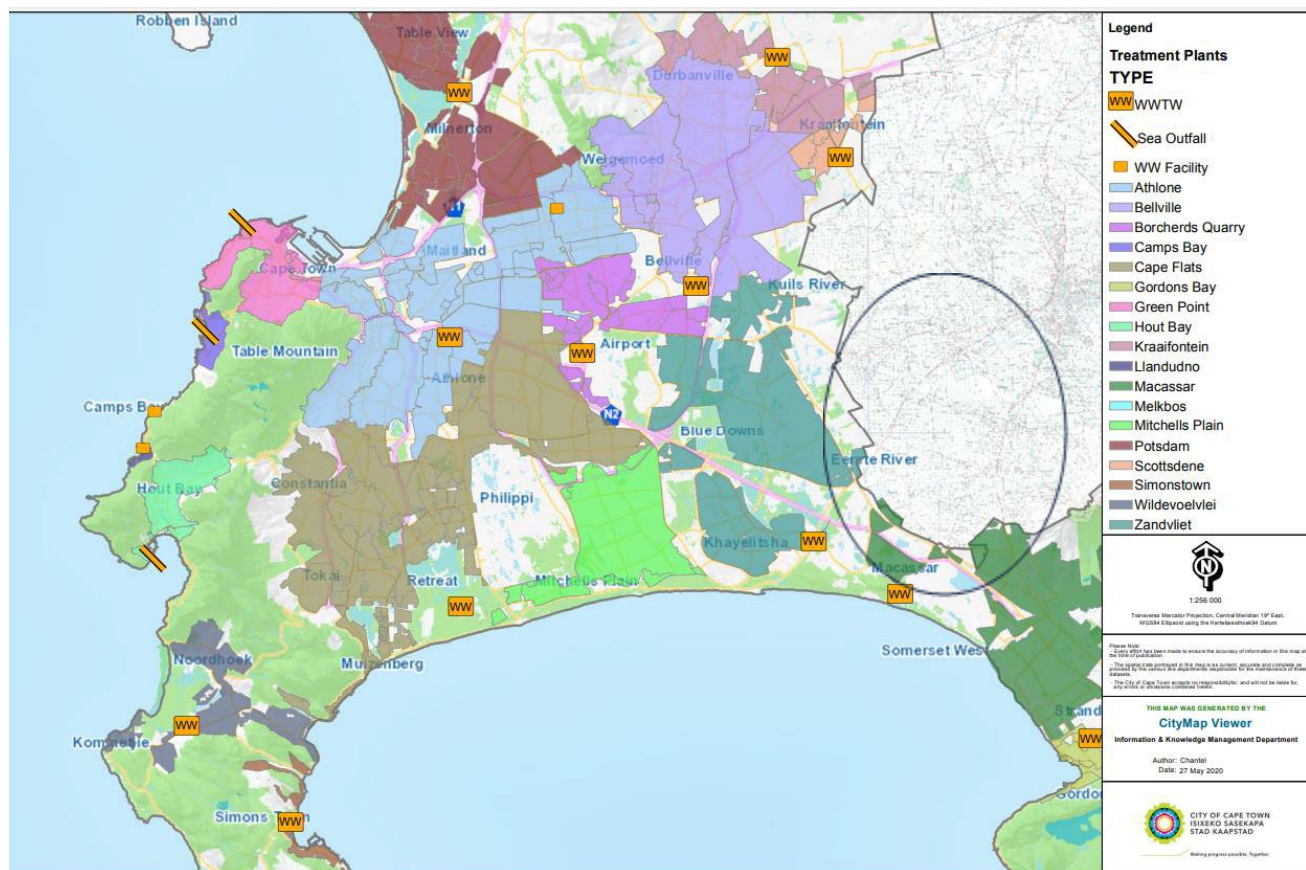
Documents made available in August 2022

- Blue Science, May 2019. *Freshwater Impact Assessment for the Proposed Faure New Water Scheme*
- City of Cape Town, March 2021: *Water Reuse in Cape Town – Frequently Asked Questions*
- City of Cape Town, 2020: *Water Reuse for Cape Town – Booklet*
- City of Cape Town, August 2020: *Water Reuse Stakeholder Engagement Strategy*
- City of Cape Town, 2018: *Our Shared Water Future, Water Strategy for the CoCT*
- City of Cape Town, 2018: *New Water Programme Plan*
- City of Cape Town, 2017: *Water Resiliance Projects: Environmental Management Programme*
- City of Cape Town, 2017: *Water Resiliance Programme: Emergency Programme Scope Definition*
- City of Cape Town, 2013: *Wastewater and Industrial Effluent Bylaw*
- Department of Water and Sanitation, 2022: *Water Use License for aspects associated with the construction of the Faure New Water Scheme.*
- Nick Helme Botanical Surveys, June 2018. *Botanical Assessment of Zandvliet Wastewater Reuse Permanent Scheme, Cape Town*
- Zutari, August 2022. *Faure New Water Scheme: Volume 1: Detailed Design Report*
- Zutari, 2021. *Faure New Water Scheme: Stakeholder Engagement Report*
- Zutari, September 2021. *Faure New Water Scheme Advanced Water Purification Plant: Final Construction Environmental Management Programme*
- Zutari, September 2021. *Faure New Water Scheme: Bulk Pipelines and Stream Rehabilitation*
- Zutari, September 2020. *Faure New Water Scheme: Ecological Assessment Report for Green Star Buildings*
- Aurecon, December 2019. *Faure New Water Scheme: Radionuclides Study*
- Aurecon, October 2019. *Water Reclamation for Potable Use Feasibility Study: Prefeasibility Assessment of Options Report*
- Aurecon, May 2019. *Faure New Water Scheme: Preliminary Design Report*
- Aurecon, February 2019. *Faure New Water Scheme: Power Generation Options Analysis - Zone 2*
- Aurecon, November 2018. *Faure New Water Scheme: Discharge Options Analysis*
- Aurecon, March 2018. *Potable Reuse of Zandvliet and Macassar Wastewater: Summary Report on Options Analysis Investigation*

Documents made available during 2023

- City of Cape Town, August 2023. *Stakeholder Engagement Strategy*
- City of Cape Town, October 2023. *Understanding Water Reuse and the Faure NWS* ("Risks and Benefits" document)
- Zutari, November 2023. *Faure New Water Scheme City of Cape Town: Derivation of LRV Targets*
- Zutari, November 2023. *Faure New Water Scheme City of Cape Town: Claimed Pathogen Log Reduction Values*
- Zutari, October 2023. *FNWS Water Quality Analysis*
- Zutari, November 2023. *Quantitative Chemical Risk Assessment*

Annexure C: Industries in the Zandvliet Catchment



Catchment Area	# of companies in Dun and Bradstreet database	Type of industries
Kuils River	858	• Paints, polyurethane • Metal works – steel, iron aluminium • Chemical processing • Agri-chemicals • Timber • Concrete • Plastic manufacturing • Paper • Tyres • Toy manufacturing • Electronics • Coca Cola • Nampak • Gas and power plants
Eerste River	471	• Cosmetics • Used oil, biofuels • Metal works – steel, iron, aluminium, and welding • Paints and waterproofing • Concrete • Fibre glass • Tyre
Khayelitsha	451	• Catering and taverns • Textiles • Petroleum • Printing

Annexure D: List of Chemicals analysed

Parameter	Parameter
General	Nutrients
Acidity	Ammonium (mg/l as NH ₄ ⁺)
Bicarbonate (mg/l)	Ammonia Nitrogen (mg/l as N)
Bicarbonate Alkalinity (calculation) (mg/l as CaCO ₃)	Combined Nitrate plus Nitrite (mg/l as N)
Calcium Hardness (mg/l as CaCO ₃)	Nitrate & Nitrite Nitrogen
Carbonate (mg/l)	Nitrate (mg/l as NO ₃)
Carbonate Alkalinity (calculation) (mg/l as CaCO ₃)	Nitrate Nitrogen (mg/l as N)
Dissolved Carbon Dioxide (mg/l)	Nitrate/Nitrite (ratio)
Magnesium Hardness (mg/l as CaCO ₃)	Nitrite (mg/l as NO ₂)
Total Alkalinity (mg/l as CaCO ₃)	Nitrite Nitrogen (mg/l as N)
Total Carbonate Species (mg/l as CaCO ₃)	Ortho Phosphate (mg/l as P)
Total Hardness (mg/l as CaCO ₃)	Phosphates (expressed as P ₂ O ₅)
Biochemical Oxygen Demand (mg/l)	Potassium (mg/l as K)
Calcium Carbonate Precipitation Potential (CCPP) as CaCO ₃	Total Inorganic Nitrogen (mg/l)
Langelier Saturation Index (LSI)	Total Kjeldahl Nitrogen (mg/l as N)
Ryzar Saturation Index (RSI)	Total Phosphate (mg/l as P)
Chemical Oxygen Demand (mg/l)	Total Phosphorous (mg/l)
Colour (mg/l as Pt)	Metals
Conductivity (mS/m) (at 25 °C)	Aluminium (µg/l as Al)
Dilute Sludge Volume Index (DSVI)	Antimony (µg/l as Sb)
Dissolved Organic Carbon (mg/l as C)	Arsenic (µg/l as As)
Mixed Liquor Suspended Solids (MLSS)	Barium (µg/l as Ba)
Odour	Beryllium (µg/l as Be)
pH (at 25 °C)	Boron (mg/l as B)
pH (at 25 °C) Field	Bromide
Redox Potential (mV)	Cadmium (µg/l as Cd)
Sodium Absorption Ratio	Cobalt (µg/l)
Temperature (°C)	Copper (µg/l as Cu)
Total Dissolved Solids (mg/l)	Cyanide (µg/l as CN ⁻)
Total Organic Carbon (mg/l as C)	Hexavalent Chromium (µg/l)
Total Suspended Solids (mg/l)	Iodine
Turbidity (NTU)	Iron (µg/l as Fe)
UV absorbance at 254 nm	Lead (µg/l as Pb)
Volatile Suspended Solids (VSS)	Lithium (µg/l)
Microplastics	Manganese (µg/l as Mn)
Inorganics	Mercury (µg/l as Hg)
Calcium (mg/l as Ca)	Molybdenum (µg/l)
Chloride (mg/l as Cl)	Nickel (µg/l as Ni)
Fluoride (mg/l as F)	Selenium (µg/l as Se)
Hydrogen Sulphide (mg/l)	Silver (mg/l as Ag)
Magnesium (mg/l as Mg)	Strontium
Reactive Silica	Thallium (µg/l)
Silicon (µg/l as Si)	Tin (µg/l)
Sodium (mg/l as Na)	Total Chromium (µg/l as Cr)
Sulphate (mg/l as SO ₄)	Uranium (mg/l as U)
Sulphide (mg/l as S)	Vanadium (µg/l)
Total Silica	Zinc (mg/l as Zn)
Disinfection Residuals	Radioactivity
Chlorate as ClO ₃	Gross alpha activity
Chlorine and chlorine based disinfectants	Gross beta activity
Chlorite as ClO ₂	40K
Free Chlorine (mg/l as Cl)	Phthalates
Free chlorine as Cl ₂	238U
Monochloramine as Cl ₂	232Th
Monochloramine as NH ₂ Cl	Bis(2-ethylhexyl) phthalate
Residual chlorine	226Ra
Disinfection By-products	Butylbenzyl phthalate
Bromate	228Ra
Bromate as BrO ₃	Diethyl phthalate
Bromodichloromethane	222Rn
Bromoform	Dimethyl phthalate
Chloroform	Di-n-butyl phthalate
Combined trihalomethane	
Dibromochloromethane	
Dichloroacetic acid (DCA)	
Monochloroacetic acid	
N-Nitroso dimethylamine (NDMA)	
Trichloroacetic acid (TCA)	
Trihalomethane Ratio	

Parameter	Parameter
General CECs	General CECs
17 α -Ethinylestradiol (EE2)	Pentoxifylline
Di-n-Octyl phthalate	Phenazone
Bendroflumethiazide	Phenytoin
Bezafibrate	Primidone
BPA	Amoxicillin (semi-quantitative)
Bromate by UV/VIS	Progesterone
Bromochloroacetic acid	Propylparaben
Butalbital	Quinoline
Butylparaben	Salicylic Acid
Caffeine	Stavudine
Carbadox	Sucralose
Carbamazepine	Sulfachloropyridazine
17 β -estradiol (E2)	Sulfadiazine
Carisoprodol	Sulfadimethoxine
Chloramphenicol	Sulfamerazine
Chlorite by IC	Androstenedione
Chlorodibromomethane	Sulfamethazine
Cimetidine (semi quantitative)	Sulfamethizole
Cotinine	Sulfamethoxazole
Dactinomycin (DACT)	Sulfathiazole
DEET	TCEP
Dehydronifedipine	TCP
DIA	TDCPP
4-tert-Octylphenol	Testosterone
Diazepam	Theobromine
Dibromoacetic acid	Theophylline (semi-quantitative)
Diclofenac	Atenolol
Diethanolamine (DEA)	Total Haloacetic Acids (HAA5)
Dilantin	Total THM
Diltiazem	Triclocarban
Erythromycin	Triclosan
Estradiol	Trimethoprim
Estriol	Warfarin
Estrone	Additional CECs
Acesulfame-K	Carbamazepine Epoxide
Ethylparaben	Amitriptyline
Flumequine	Cetirizine
Fluoxetine	Citalopram
Gemfibrozil	Losartan
Ibuprofen	Amphetamine
Iohexol	Benzotriazole
Iopamidol	Dexamethazone
Iopromide	Dolutegravir
Isobutylparaben	Doxycycline
Ketoprofen	Nalidixic acid
Acetaminophen (Paracetamol)	Natamycin
Ketorolac	Ofloxacin
Lidocaine	Omeprazole
Lincomycin	Propylphenazone
Lopressor	Rifampicin
Meclofenamic Acid	Sildenafil
Meprobamate	Teno prodrug
Metformin	Tramadol (qualitative)
Methylparaben	Lopinavir
Monobromoacetic acid	Nevirapine
Naproxen	Ritonavir
Albuterol	Zidovudine
N-ethyl Perfluorooctanesulfonamidoacetic acid	Zidovudine glucuronide
Nifedipine (semi quantitative)	Cocaine
N-methyl Perfluorooctanesulfonamidoacetic acid	Epitestosterone
N-Nitrosomorpholine (NMOR)	Oxybenzone
Norethisterone	Propranolol
Oxolinic acid	Venlafaxine

Parameter	Parameter
Herbicides & Pesticides	Herbicides & Pesticides
1,2-dibromo-3-chloropropane	Diaminotriazine
2,4,5-T	Diazinon
2,4,5-TP	Dichlorvos
2,4-D	Dichlobenil
2,4-DDE	Dichlobutrazole
2,4-DDT	Dichlofluanid
4,4-DDE	Dichlon
4,4-DDT	Dichlorodiphenyltrichloroethane (DDT) and metabolites (cumulative)
Abamectin	Dichlorprop (Free Acid) (including Dichlorprop-P)
Acephate	Dichlorvos
Acetamiprid	Dicloran
Acetochlor	Didecyldimethylammonium Chloride
Acifluorfen	Dieldrin
Aldicarb	Difenoconazole
Aldicarb Sulphone (Aldoxycarb)	Diffubenzuron
Aldicarb Sulphoxide	Dimethoate
Allethrin	Dimethomorph
Alpha-BCH	Dinitramine
Amitrols	Dinoseb
Atrazine	Diquat
Atrazine and its chloro-s-triazine metabolites (cumulative)	Disulphoton
Azinphos-ethyl	Diuron
Azinphos-methyl	Dodine
Azoxystrobin	Emamectin
Benomyl	Endosulfan (Sum of alpha, beta endosulfan and endosulfan sulphate)
Benzalkonium Chloride - 10	Endothall
Benzalkonium Chloride - 12	Epoxiconazole
Benzalkonium Chloride - 14	Etaconazole
Benzalkonium Chloride - 16	Ethion
Beta-BHC	Ethofumesate
Bifenthrin (sum of isomers)	Ethoprophos (Mocap)
Bitertanol	Etiozole
Boscalid	Etrimphos
Bromacil	Famoxadone
Bromopropylate	Fenamidone
Buprofezin	Fenamiphos
Cadusafos	Fenarimol
Carbaryl	Fenazaquin
Carbendazim and benomyl (sum of benomyl and carbendazim expressed as carbendazim)	Fenbuconazole
Carbofuran	Fenbutatin-Oxide
Carbophenothion	Fenhexamid
Chinomethionate	Fenitrothion
Chloramizol (Imazalil)	Fenoxycarb
Chlorantraniliprole	Fenpropathrin
Chlordane (sum of cis- and trans-chlordane)	Fenpyroximate
Chlorfenvinphos	Fenthion
Chloridazon	Fentin Hydroxide
Chlorothalonil	Fenvalerate (Sum of isomers, including esfenvalerate)
Chlorotoluron	Flubendiamide
Chlorphenapyr	Fludioxonil
Chlorpyrifos	Flufenoxuron
Chlorpyrifos-methyl	Fluopicolide
Chlorthal-dimethyl	Fluroxypyr
Clofibric Acid	Flusilazole
Clothianidin	Formetanate
Coumaphos	Gamma HCH (Lindane)
Cyanazine	Garlon 4
Cycloxidim	Glyphosate
Cyfluthrin (cyfluthrin including other mixtures of constituent isomers (sum of isomers))	Haloxypol (haloxypol esters, haloxypol and its conjugates, expressed as haloxypol)
Cymoxanil	Heptachlor
Cypermethrin (cypermethrin including other mixtures of constituent isomers (sum of isomers))	Heptachlor Epoxide
Cyprodinil	Hexachlorobenzene
Deethyl-atrazine	Hexaconazole
Deisopropyl-atrazine	Imidacloprid
Deltamethrin	Indoxacarb
Demeton-S-Methyl	Iprodione
Demeton-S-methyl Sulphone	Iprovalicarb

Parameter	Parameter
Herbicides & Pesticides	Herbicides & Pesticides
Isobenzan (Telodrin)	Spinosad
Isodrin	Spirodiclofen
Isufenphos	Spirotetramat (BYI08330-enol, BYI08330-ketohydroxy and BYI08330-enol-glucoside), expressed as Spirotetramat
Isoproturon	Spiroxamine
Kresoxim-methyl	Sulfoxaflor
Lambda-cyhalothrin (includes gamma-cyhalothrin) (sum of R,S and S,R isomers)	tau-Fluvalinate
Linuron	Tebuconazole
Lufenuron	Tecnazene
MCPA	Teflubenzuron
Mefenoxam (Metalaxyl)	Tetradifon
Mercaptothion	Thiabendazole
Metazachlor	Thiacloprid
Methamidophos	Thiadiazuron
Methidathion	Thiamethoxam (Sum of thiamethoxam and clothianidin, expressed as thiamethoxam)
Methiocarb (Sum of Methiocarb, its sulphone & sulfoxide)	Thiophanate
Methomyl	Thiophanate-methyl
Methoxychlor	Toxaphene
Methoxyfenocide	Triadimefon
Metolachlor	Triadimenol
Metrafenone	Triallate
Metribuzin	Triazophos
Mevinphos	Trichlorfon
Molinate	Triclopyr
Monocrotophos	Trifloxystrobin
Monuron	Trifluralin
MSMA	Uniconazole
Myclobutanil	Vamidothion
Nitralin	Vinclozolin
Novaluron	Zoxamide
Omethoate	Phenols
OUST (sulfameturon-methyl)	2,4,5-Trichlorophenol
Oxamyl (sum of oxamyl and its oxime expressed as oxamyl)	4-Nitrophenol
Oxydemeton-methyl	Pentachlorophenol
Oxyfluorfen	2,4,6-Trichlorophenol
Paraquat	2,4-Dichlorophenol
Parathion-ethyl	2,4-Dimethylphenol
Parathion-methyl	2-Chlorophenol
PCNB	2-Methylphenol
Penconazole	2-Nitrophenol
Pendimethalin	4-Chloro-3-methylphenol
Penthiopyrad	4-Methylphenol
Permethrin (sum of isomers)	Polycyclic Aromatic Hydrocarbons
Phenthoate	Acenaphthene
Phosalone	Dibenzo(ah)anthracene
Phosmet	Fluoranthene
Phoxim	Fluorene
Piperonyl Butoxide	Indeno(123cd)pyrene
Pirimicarb	Naphthalene
Pirimiphos-methyl	Phenanthrene
Prochloraz	Pyrene
Profenofos	Acenaphthylene
Propamocarb	Anthracene
Propargite	Benzo(a)anthracene
Propazine	Benzo(a)pyrene
Propiconazole (sum of isomers)	Benzo(b)fluoranthene
Propiconazole (sum of isomers)	Benzo(ghi)perylene
Propoxur	Benzo(k)fluoranthene
Propyzamide	Chrysene
Proquinazid	PCBs
Prothiofos	PCB 28
Pymetrozine	PCB 52
Pyraclostrobin	PCB 101
Pyrimethanil	PCB 118
Pyriproxyfen	PCB 138
Quinoxifen	PCB 153
Simazine	PCB 180
Spinetoram	

Parameter	Parameter
Volatile & Semi-Volatile Organic Compounds	Volatile & Semi-Volatile Organic Compounds
1,1,1-trichloroethane	Dichlorodifluoromethane
1,1-dichloroethene	o-cresol
1,2-dibromo-3-chloropropane	1,1-Dichloroethene (1,1 DCE)
1,1-Dichloropropene	p-chloro phenol
1,2,3-Trichlorobenzene	p-cresol
1,2,3-Trichloropropane	Phenols (µg/l)
1,2,3-trihydroxy benzene	tert-Butylbenzene
1,2,3-Trimethylbenzene	p-nitro phenol
1,2,4-Trichlorobenzene	Propylbenzene
1,2,4-Trimethylbenzene	Tetrachloroethene (PCE)
1,2-Dibromoethane	trans 1,2- dichloroethene
1,2-dibromomethane	Pyridine
1,2-Dichlorobenzene	trans-1-3-Dichloropropene
1,2-Dichloroethane	sec-Butylbenzene
1,2-Dichloroethene	trans-1-2-Dichloroethene
1,2-Dichloropropane	Styrene
1,3,5-Trimethylbenzene	trans-1-3-Dichloropropene
1,3-Dichlorobenzene	Surrogate Recovery 4-Bromofluorobenzene
1,3-Dichloropropane	Surrogate Recovery Toluene D8
1,4-Dichlorobenzene	Trichloroethene (TCE)
1,4-Dioxane	Trichlorofluoromethane
1,7-Dimethylxanthine	1,1,2-Trichloroethane
1-methyl naphthalene	Dichloromethane (DCM)
1-naphthol	di-methyl naphthalene
2-cis 1,2 dichloropropene	Diphenyl oxide
2,2-Dichloropropane	Dodecyl phenol
2,4-dinitro phenol	Endosulfan
2,6-dimethyl phenol	Endrin
2-Chlorotoluene	Florene
2-methyl naphthalene	Hexachloro ethane
2-naphthol	Hexachlorobutadiene
2-nitropropane	Iso-propyl mysistate
3,4,5-Trichlorophenol	1,1-dichloroethane
3,4,5-tetrachloro phenol	Isopropylbenzene
1,1,1,2-Tetrachloroethane	Iso-tridecanol
3,4-dimethyl phenol	Linalyl acetate
3,5-dimethyl phenol	m-cresol
4-Chlorotoluene	Methylene chloride
4-Isopropyltoluene	Monochlorobenzene
4-nonylphenol - semi quantitative	n-Butylbenzene
Acrylamide	n-propylbenzene
Aldrin	O and pdichlorobenzene
Aniline	Fuel VOCs
Aroclor 1254 and 1260 (PCB's)	Trietanol amine
Benzonitrile	Benzene
1,1,1-Trichloroethane	Ethylbenzene
Biphenyl	Vinyl Chloride
Bis-chloroethylether	Methyl Tertiary Butyl Ether (MTBE)
Bromobenzene	Tert-amyl methyl ether (TAME)
Bromochloromethane	Toluene
Bromomethane	m-Xylene
C9 — C26 Alkanes	p-Xylene
Carbazole	o-Xylene
Carbon Disulphide	Xylenes (sum of isomers)
Carbon tetrachloride	Fuel Hydrocarbons
Cetyl alcohol	EPH >C8-C10
1,1,2,2-Tetrachloroethane	Total petroleum hydrocarbons-diesel range organics (TPH-DRO)
Chlorobenzene	EPH >C10-C12
Chloroethane	EPH >C12-C16
Chloromethane	EPH >C16-C21
cis-1-2-Dichloroethene	EPH >C21-C35
cis-1-3-Dichloropropene	EPH >C21-C40
DDT	EPH >C35-C40
Dibenzo(a,h)anthracene	EPH >C8-C40
Dibezo furan	Total petroleum hydrocarbons-gasoline range organics (TPH-GRO)
Dibromomethane	

Parameter
ARVs and TB Meds
Abacavir (ABC)
Efavirenz (EFV)
Emtricitabine (FTC)
Ethambutol
Isoniazid
Lamivudine
Pyrazinamide
Rifampin
Tenofovir (TDF)
Recreational Drugs
Benzoylecgonine
Codeine
MDMA
Methamphetamine
Methaqualone
PFAS
Perfluorobutanesulfonic acid (PFBS)
Perfluorooctanoic acid (PFOA)
Perfluorotetradecanoic acid (PFTeDA)
Perfluorotridecanoic acid (PFTrDA)
Perfluoroundecanoic acid (PFUnA)
Perfluorobutanoic acid (PFBA)
Perfluorodecanoic acid (PFDA)
Perfluorododecanoic acid (PFDoDA)
Perfluoroheptanoic acid (PFHpA)
Perfluorohexanesulfonic acid (PFHxS)
Perfluorohexanoic acid (PFHxA)
Perfluorononanoic acid (PFNA)
Perfluorooctanesulfonic acid (PFOS)
HFPO-DA (Gen X)
Perfluorooctadecanoic acid (PFODA)
Sodium perfluoro-1-tridecanesulfonate (PFTIDS-Na)
Perfluoropentanoic acid (PFPeA)
Perfluoropentane sulfonic acid (PFPeS)
6:2 fluorotelomer sulfonate (6:2 FTS)
MeFOSA
Perfluorodecane sulfonic acid (PFDS)
Perfluoroheptanesulfonic acid (PFHps)
8:2 Fluorotelomer sulfonic acid (8:2 FTS)
NEtFOSA
8:2diPAP
Perfluorohexadecanoic acid (PFHxDA)
Perfluorononanesulfonic acid (PFNS)
FOUEA
Perfluorooctanesulfonamide (PFOSA)
9CI-PF3ONS
4:2 Fluorotelomer sulfonic acid (4:2 FTS)
Perfluoroundecanesulfonic acid (PFUnDS)
5:3 Fluorotelomer carboxylic acid (5:3 FTCA)
4,8-dioxa-3H-Perfluorononanoic Acid (DONA)

Annexure E: Example of a List of Surrogate Chemicals

Example of a list of surrogate or indicator parameters developed for a Reverse Osmosis water reclamation plant in Perth, Australia.¹⁷ As the Faure NWS is a carbon-based plant, a different list of surrogates will need to be developed from the chemicals that are present in its source catchment as established by the QCRA.

Table 7: RWQI for groundwater replenishment in the Beenyup wastewater catchment

RWQI	Unit	Guideline Value ⁽¹⁾	Limit of reporting	Chemical Group that they represent
Boron	mg/L	4	0.02	Inorganic chemicals
N-nitrosodimethylamine (NDMA)	ng/L	100	1	Nitrosamines
Nitrate as nitrogen	mg/L	11	0.01	Inorganic chemicals
Chlorate	mg/L	0.7	0.01	Inorganic disinfection by-products
1,4-Dioxane	ug/L	50	0.1	Organic chemicals
Chloroform	ug/L	200	0.05	Other disinfection by-products
Fluorene	ug/L	140	0.1	Organic chemicals
1,4-dichlorobenzene	ug/L	40	0.05	Organic chemicals
2,4,6-trichlorophenol	ug/L	20	1	Phenols
Carbamazepine	ug/L	100	0.05	Pharmaceuticals and personal care products
Estrone	ng/L	30	1	Hormones
EDTA	ug/L	250	10	Organic chemicals
Trifluralin	ng/L	50000	1	Pesticides and herbicides
Diclofenac	ug/L	1.8	0.05	Pharmaceuticals and personal care products
Octadioxin	pg/L	9000	2	Organic chemicals
MS2 Coliphage	pfu/L	<1	0.6	Microorganisms / Pathogens
Alpha particle activity	mBq/L	500	10	Radioactive compounds
Beta particle activity (-K40)	mBq/L	500	10	Radioactive compounds

(1) Sampled results should be equal to or less than the guideline value.

¹⁷ Law, I.B., 2022. *Source Control in Advanced Reuse Applications – International Trends*. Paper presented to the Trade Waste Control Group of Water Services Association of Australia (WSAA), 27th July 2022

Notes

