WATER RESEARCH COMMISSION

WORKING PAPER

Strengthening the implementation of water reuse in South Africa

N. Kalebaila, EJ Ncube, CD Swartz, S Marais and J Lubbe

Abstract

Pressures from climate change and the rising demand for freshwater water resources by different users, population growth, and rapid urbanisation and poor water quality have put a lot of pressure on freshwater supplies. Consequently, there has been more and frequent consideration of using alternative water sources. Amongst these, water reclamation and reuse has been promoted as a strategic option with a potential in assisting countries to meet their development goals. With South Africa also recognised as a water stressed country, the need for wastewater reclamation and reuse has become urgent. Evidence from planned and existing cases show that the pace of implementation within the water services sector has been slowed by a combination of socio-political, technical and economic factors. However, water supply authorities are increasingly becoming aware that water reuse is not only an emergency supply option anymore, but must be considered as part of a long-term water supply mix strategy in water resources planning. This paper provides a brief context of planned water reuse as part of an integrated water resources strategy and an outlook on the current status of water reclamation and reuse in South Africa, in terms of governance, current reuse applications, main barriers to widescale implementation of planned municipal water reuse projects and some recommendations/opportunities for addressing the identified challenges.

Introduction

South Africa suffers from chronically overburdened water resources due to insufficient water infrastructure maintenance and investment, recurrent droughts driven by climatic variation, inequities in access to water and sanitation, deteriorating water quality, and a lack of skilled water engineers (DWS, 2018). If these current conditions prevail, it is estimated that South Africa could face a water deficit of 17% by 2030 (WWF, 2017). However, this problem is not unique to South Africa, as a matter of fact, the available freshwater resources in many other countries around the world is not sufficient to meet the rising demand, pushing these countries into extreme stress. To put this into perspective, it is estimated that nearly two-thirds of the world's population live in areas that experience severe water scarcity – in terms of withdrawing more than is returned or replenished by a factor of two or more – for at least one month a year (Mekonnen and Hoekstra, 2016). Moreover, it is predicted that climate change will lead to increased periods of drought, reduced freshwater stores, and sea level rise (IPCC, 2018), further exacerbating the water quantity and quality situation of the world's water resources. Water is central to life, water shortages can lead to water stress impacting human and environmental health, livelihoods, as well as economic growth and development within the agriculture, industry and other sectors.

The current National Water and Sanitation Master Plan (NW&SMP) is a detailed plan on the priority actions that must be implemented in South Africa by 2030 in order to address the current water crisis, as well as future water challenges that may impact sustainable development in the country (DWS, 2018). These actions are clustered into two strategic areas, namely: (1) Water and sanitation management and, (2) Creating an enabling environment. One of the issues addressed under the Water and sanitation management strategic area is the need to reduce demand and increase supply, and the reuse of treated effluent (water reclamation and reuse) is recognised as one of the potential interventions to augment water supply. Water reclamation refers to the process of treating or processing of wastewater to make it reusable with definable treatment reliability and meeting appropriate water quality criteria, whereas, water reuse refers to the activity of using the treated wastewater (or reclaimed water) for a beneficial purpose (Swartz et al., 2015). A list of other definitions related to water reclamation and reuse is provided in Annexure 1. Apart from supplementing water supplies, water reclamation and reuse has potential for addressing the excessive pollution of water resources, supporting circularity and job creation, and overall contributing to sustainable development (Tortajada, 2020; Asano et al., 2007). Globally, the potential role of water reuse in the achievement of the 2030 Sustainable Development Goals (SDGs) has been widely acknowledged. Therefore, in the coming years, the pace for water reuse and reclamation implementation is expected to rise significantly, due to countries' commitments to SDGs. It is estimated that the global market for wastewater recycling and reuse will reach US$ 22.3 billion by 2021, from the US$ 12.2 billion estimated in 2016 (IWA, 2018).

This paper provides a brief context of planned water reuse as part of an integrated water resources strategy and an outlook on the current status of water reclamation and reuse in South Africa, in terms of governance, current reuse applications, main barriers to widescale implementation of planned municipal water reuse projects and some recommendations/opportunities for addressing the identified challenges. The recommendations, mainly focussed on supporting municipal water reuse schemes, cite the different aspects that should be considered from planning to implementation, i.e., water reuse governance (policy and regulations, economics, stakeholder participation and public acceptance), treatment technology and water quality (health and safety) and water reuse within the circular economy context objectives.

Water reuse as part of national integrated water resources planning and management

South Africa is classified as a water scarce country, receiving an average annual rainfall of 465 mm, which is almost half of the global average annual rainfall of 814 mm (DWS, 2018). Almost 60% of South Africa's surface water runoff is generated from only 20% of our land surface area, while most of our rivers are also highly seasonal (WWF, 2017). To manage water supply and demand, South Africa has always followed a supply-oriented water management or traditional water resource planning and management approach. This approach was well supported by intensive research leading to the development of a number of innovative, highly sophisticated and internationally recognised water resources planning and management decision support models and tools were developed. Application of these models and tools for water resources management enabled the implementation of highly complex bulk water transfer schemes, integrated storage and water supply systems involving both surface and groundwater systems in South Africa (Bailey and Pitman, 2017). However, the 1990s brought with it the global realisation that water is both a social and economic good, which it needs to be allocated equitably. In addition, the need to develop and manage all water resources in a well-coordinated, integrated and sustainable manner in order to meet the rising demand was recognised (van Koppen and Schreiner, 2013).

As a result, the concept of integrated water resource management (IWRM) as an approach to water management was put on the international water agenda at the UN Conference on Environment and Development in Dublin in January 1992 and later adopted for implementation by a number of countries, including South Africa (UN, 2018). It is within this context that post-1994; new water policies and legislation promoting integrated and sustainable water resources management and access to all for water services were promulgated in South Africa. These policies include the Water Supply and Sanitation Policy in November 1994, the White Paper on a National Water Policy for South Africa in 1997, promulgation of the Water Services Act (Act 108 of 1997) in 1997 and the National Water Act (Act 36 of 1998) in 1998 (van Koppen and Schreiner, 2013). The National Water Resource Strategy (NWRS), which is based on the 1997 White Paper on a National Water Policy and the National Water Act of 1998, is the main strategic policy document that provides the framework for implementation of integrated management of water resources in South Africa (DWAF, 2004). In recognition of the consistent rise in water demand and deterioration in the quality of water resources, the current NWRS (NWRS II) emphasizes on the need to diversify the portfolio of water sources by considering non-traditional water supply options such as water reclamation and reuse, desalination (coastal or groundwater), rainwater and greywater and stormwater harvesting and use as part of water resources planning and management. As a matter of priority for implementation, a dedicated National Strategy for Water Reuse was developed as part of NWRS II (DWA, 2013).

In accordance with the National Water Act and NWRS II, the Department of Water and Sanitation (DWS) has to conduct periodic water reconciliation strategies in order to provide a decision support framework and tools, which will enable timely decisions on integrated water resource interventions to meet the future water requirement. The first phase for the development of comprehensive water reconciliation strategies for towns, villages and clusters of villages was concluded in 2011. Phase 2, aimed at monitoring the implementation progress of water supply options at each of these towns commenced in 2012) (Thompson, Riemann and Hay, 2015). However, to date, the integration and implementation of these options (particularly water reclamation and reuse) as part of a water supply mix within the water services delivery environment is still lagging behind. The current National Water and Sanitation Master Plan (NW&SMP) aims to fast track the implementation of priority actions, including water reuse, in order to address the current water crisis, as well as future water challenges that may impact sustainable development in the country (DWS, 2018).

Legislative and institutional framework of water reuse within water services delivery

The role of water reuse as part of the portfolio of water sources in order to meet the growing demand for water supply in South Africa is well recognized. With regards to the implementation, the planning and commissioning of water reuse projects is guided by a number of policy documents and governed by a number of legislations across different government departments (Turner et al., 2015). The National Water and Sanitation Master Plan as well as in the National Water Resources Strategy II and accompanying National Water Reuse Strategy are some of the key policy documents. The South African Constitution (Act No. 107 of 1996) and the Water Services Act (Act No. 108 of 1997) provide the legislative framework with regards to delivery of water and sanitation services in South Africa. With regards to water resources use and protection, the National Water Act (Act 36 of 1998) provides regulations related to water resources use (abstraction) for treatment and distribution, as well as those for wastewater discharge into water resources, in terms of water resources protection. Wastewater discharge into the marine environment is governed by regulations issued in terms of Section 83 (1)f and 83 (1)g of the National Environmental Management: Integrated Coastal Management Act, 2008 (Act No. 24 of 2008) under the Department of Environment, Forestry and Fisheries (DEA, 2014). The sections below highlight the extent to which the current legislative and institutional arrangements promote the implementation of water reuse within local government.

- **Recognition of wastewater as a resource for reuse**

It is within the scope of the Minister of the Department of Water and Sanitation to develop and enforce regulations for water resources use (and abstraction) and protection, in accordance with the National Water Act. However, the National Water Act, does not explicitly recognise wastewater as a resource. Thus, in terms of this Act, water service institutions have an obligation to return the treated wastewater into the resource in order to maintain streamflow and environmental water balance, and through the Green Drop incentive-based regulation programme also ensure that the discharge is of acceptable quality such that it does not result into water resources pollution. In particular, for inland plants, this means that a certain portion of wastewater effluent can be authorised for recycling. Unlike inland municipalities, the discharge of treated wastewater into the marine environment by coastal municipalities is governed by the Department of Environment, Forestry and Fisheries (DEFF) through the National Guideline for the Discharge of Effluent from Land-based Sources into the Coastal Environment published in terms of Section 83 (1) f and 83 (1) g of the National Environmental Management: Integrated Coastal Management Act, 2008 (Act No. 24 of 2008) (DEA, 2014). As coastal cities discharge into the sea, their potential for reuse is higher, compared to inland municipalities due to possible obligations for returning the treated wastewater into the resource.

While a familiar concept, resource reuse and recycling is yet to be fully integrated into South African water policies and legislation. However, the circular economy concept, a revised version of the ancient 3R concept, has recently found expression in a number of other South African policy documents, such as the Science, Technology and Innovation White Paper of 2019 (DST, 2019). In the same year, this aspect was also included in the National Waste Management Strategy proposed by the Department of Environment, Forestry and Fisheries (DEFF, 2019). In the absence of specific regulations, the implementation of water reuse within municipalities has been dealt with on a case-by-case basis. Hopefully, these initiatives will give impetus to the inclusion of the same concept in the water sector legislation.

- **Role of local government in water supply planning and management**

The Water Services Act (Act 108 of 1997) mandates municipalities to develop and adopt Water Services Development Plan (WSDP) every 5 years (with annual review) through a consultation process with stakeholders, including consumers. The WSDP focuses on steps that municipalities plan to take for water service provision, water demand management and wastewater treatment. One of the business elements under the WSDP concerns profiling the quality and quantity of water resources (mostly surface and groundwater) available to the municipality. At present there is no single legislation that mandates and specifies that municipalities conduct integrated water resources planning. Integrated resources planning is a core function of the national Department of Water and Sanitation as mandated through the National Water Act (Act 36 of 1998) and envisioned in the National Water Resources Strategy. Where available, information from water reconciliation strategies on water supply options (including water reuse) compiled by DWS can be incorporated into the WSDP for implementation (Burke, 2007). In view of this gap, the National Strategy for Water Reuse calls for the need to establish implementation agencies, whose purpose would be to support the implementation of water reuse within water service institutions (van Niekerk and Schneider, 2013).

In terms of stakeholder participation, both the integrated water resources management approach (as conveyed in the National Resources Strategy) and WSDP processes include an element of stakeholder and consumer engagement, however, the extent to which that both are conducted remain unclear. Specifically, the National Strategy for Water Reuse calls for the development and implementation of a communication strategy to engage stakeholders and the public on water reuse. The National

Strategy for Water Reuse also identifies a number of considerations for the implementation of water reuse, including the following:

- There is wastewater effluent produced from municipal wastewater treatment plants to support a business case for wastewater reclamation and reuse.
- Adequate identification of contaminants released into the aquatic environment is being conducted through research and development.
- Risk assessments have successfully been conducted and the risks to aquatic ecosystems and human health are currently known.
- Appropriate technologies for water reclamation and reuse for various purposes are available and acceptable.

- **Water quality specifications and charges**

The Water Services Act (Act No. 108 of 1997) spells out specific regulations on the quality of water to be supplied by municipalities and also provides for the setting of national standards and norms and standards for water tariffs. The norms and standards for water services tariffs allow for the differentiation of tariffs on an equitable basis by differentiating between users, types of water services and considering socio-economic and physical attributes of geographic areas. However, these tariffs are aligned to the requirement for municipalities to supply drinking quality standard water that meets the South African drinking water quality standards (SANS 241). Similar, to the lack of clarity on resources use, the supply of non-potable water and corresponding tariffs is normally addressed on case-by-case basis. Considering current legislation, potable water reuse can be regarded as the default reuse application for implementation within local government. This aspect may be limiting as it is cost-effective to supply less treated water for non-potable uses, such as agriculture. Thus, there is a need to clarify the scope of reclaimed water supply, in terms of water quality and charges, within local government.

Current status of water reclamation and reuse implementation

Currently, South Africa mainly depends on surface and groundwater resources to meet most of its household, municipal, industrial and agricultural water demands. With the current water demands, South Africa is projected to experience a water deficit of 17% by 2030. Globally, water scarcity has been identified as one of the key drivers for water reuse. Therefore, a number of water reuse schemes have been implemented to date (DWA, 2013), with a number still planned for the future. Some of the key planned and unplanned water reuse applications are highlighted below.

- **Artificial aquifer recharge**

The first indirect water reuse scheme via groundwater recharge was commissioned in the mid-1070s in Atlantis, Cape Town. The Atlantis aquifer is artificially recharged using a combination of stormwater runoff and treated domestic wastewater. The Atlantis Water Supply Scheme (AWSS) uses the stored groundwater as source to treat to drinking water quality for use by the adjacent communities. Over the years, the Department of Water and Sanitation has made numerous attempts to replicate the practice of managed aquifer recharge (MAR) using treated wastewater in other towns, however, none have been as successful as the Atlantis scheme (Bugan et al., 2016).

- **De facto water reuse in agriculture**

In South Africa, water reuse account for approximately 14% of total water use and return flows account for a large part of water available for use from some of the important river systems. The largest surface water-using sector in South Africa is irrigated agriculture, and accounts for 61% of the withdrawals from surface water sources (DWS, 2018). While this water is often perceived as freshwater, however, it mostly comprises of a proportion of wastewater from the return flows. This constitutes an unplanned indirect (de facto) water reuse practice. This situation is not unique for South Africa, but is on par with global practice, where it has been estimated that about 65% of irrigated croplands downstream of urban areas are located in catchments affected by urban wastewater flows (Thebo et al., 2017). In terms of the volumes used, water reuse for agriculture has high potential to play an important role in integrated water resources management.

- **De facto potable water reuse**

The practice of de facto water reuse is widespread in South Africa and is not only limited to the agricultural sector, but also in the municipal sector as most drinking water treatment plants are situated downstream from a wastewater treatment works. Thus, most of the country's municipal drinking water treatment plants reuse wastewater inadvertently. Currently, a study is underway to quantify the extent of de facto reuse in South Africa.

- **Planned industrial and municipal water reuse**

Table 1 shows examples of the recent planned direct and indirect water reuse projects in South Africa. An extended list of case studies can also be found in Appendix A of the NWRS II (DWA, 2013). Compared to municipalities, water reuse in industry has been practised for a while now. The Durban Water Recycling plant is one of the most successful and earliest planned water reuse projects to be successfully implemented for direct industrial reuse.

Table 1: Examples of current and planned water reuse schemes in South Africa

Location	ML/d	Capital costs[a]	End use	Status
Durban Water Recycling plant	47.5	R74 million	Direct industrial	Commissioned in 2001
Emalahleni WRP	30		Direct potable	Commissioned in 2007
Optimum Coal WRP	15	R600 million	Direct potable	Commissioned in 2010
Mossel Bay	5	R40 million	Direct industrial	Commissioned in 2010
George	8,5	R36 million	Indirect potable	Commissioned in 2010
Beaufort West	2,1	R26.5 million	Direct potable	Commissioned in 2010
eThekwini water reuse project	116	N/A	Direct potable	Halted in 2012
Frasers WWTW	3		Direct potable	Commissioned in 2016
eThekwini Remix plant	6.25		Direct potable	Pilot demonstration (2019)
City of Cape Town		N/A	Direct reuse	Pilot demonstration
Umgeni Water		N/A	Direct reuse	Pilot demonstration
Port Elizabeth (NMBM)		N/A	Industrial reuse	Feasibility and Tender
Hermanus (Overberg)		N/A	Direct potable	Feasibility and Tender

a = at time of construction, WRP = water reclamation plant

The Emalahleni water reclamation plant is another successful example, where industrial wastewater (mine water) is treated to drinking water standards. Beaufort West municipality holds the distinction of having South Africa's first and municipal owned direct potable reuse plant, where secondary treated wastewater is conveyed to an advanced water treatment facility for further treatment to drinking water quality standards. The Beaufort West water reclamation plant was commissioned in 2010 when the town's main water supply, the Gamka Dam, dried up during a severe drought, and became operational in January 2011. Although the drought was broken in June 2011 by widespread rains in the central Karoo and Garden Route, the Beaufort West region is currently experiencing a very harsh drought, probably even worse than in 2010. The water reclamation project is proving to be a reliable source of water for the town, albeit not sufficient on its own to meet the water demand of the community and industry. Similar to the Beaufort West reclamation plant, the George, Mossel Bay and Beaufort West water reclamation plant were constructed during the 2010/11 drought period. From these examples, it is clear that potable water reuse schemes have been in implemented in South Africa as short-term and small-scale interventions in response intervention to recurring droughts. These projects were mostly undertaken under emergency conditions and considerable time pressure, which differentiate them from the projects not completed under such strict time constraints (Turner et al 2015).

In 2009, the eThekwini Metropolitan municipality initiated a feasibility study for implementing a direct potable water reuse scheme in order to meet a projected 1.5% increase in water demand within their jurisdiction. A public participation process, as part of the requirements of an Environmental Impact Assessment (EIA) study was undertaken. However, due to a number of public objections, implementation of this scheme was halted in 2012 (Golder Associates Africa, 2012). A later analysis to this case study showed that the most distinctive objection came from Muslims who believed that this practice was not permissible. After engaging the Muslim leaders and community on aspects of water purification, it was agreed by all parties that religion does not seem to be a major impediment in water reclamation practices (Tayob, Deedat and Patel, 2015). Engaging this aspect of planning and implementation of potable water reuse projects and educating the public on aspects of water reuse has paved way for the successful implementation of an additional 2 water reuse schemes (Frasers WWTWs and eThekwini Remix plant) within the region. In addition, in the last 5 years, there has been a shift in the planning and implementation of water reuse, with such projects conceptualised as part of a long-term strategy for meeting future water demands, the recent City of Cape Town's Water Strategy document is a good example (City of Cape Town, 2020). The number of medium to large scale municipal water reuse projects that are in planning or pilot demonstration phases, indicating significant gear up in the pace of water reuse implementation.

Barriers for widescale adoption of water reclamation and reuse

By 2040, South Africa is planning to increase the dependency on water reuse from 14 to 18%, and thus it is within national imperatives (i.e. the NW&SMP) to increase the number of water reuse schemes or capacity in the country (DWS, 2018). Currently, a number of additional municipal water reuse projects are planned, however, it is no indication that these will go ahead as planned and the goal will be achieved. Considering the current capacity of operational wastewater treatment plants and existing planned water reuse schemes, wastewater is still an underutilised resource. To put this into perspective, there are about 824 wastewater collector and treatment facilities in South Africa, with a collective hydraulic design capacity of 6509 ML/day. Of these, 59 are macro wastewater treatment works (i.e. have a capacity of >25 ML/day), and account for 65% of the wastewater capacity in the country. Collectively, these plants have a hydraulic capacity of about 4000 ML/day, and an estimated potential water reuse capacity of about 2500 ML/day capacity. Of this capacity, 1100 ML/day is accounted for by about 5 coastal cities, compared to the rest (1400 ML/day) that is contributed by the numerous inland cities. The slow pace of water reuse implementation in South Africa has been attributed to a number of complex interrelationships between technological, economic, and socio-political factors. These aspects have been well reported by a number of South African researchers (DWA, 2013; van Niekerk and Schneider, 2013; Swartz et al., 2015; Muanda et al 2017; Slabbert and Green, 2019). Among these, socio-political factors have been reported to play far more an important role in hindering the widescale implementation of planned water reuse, compared to technical and economic factors. These factors are briefly discussed below.

- **Socio-political factors**

Socio-political factors include; lack of a clear water reuse governance framework, institutional fragmentation, lack of a clear regulations on water reuse, limited long-term strategic planning, lack of implementation capacity and skills, lack of communication and collaboration between stakeholders, lack of public knowledge regarding water reuse and lack of stakeholder and community participation. As an example, a later analysis of the eThekwini case study showed that, a lack of public knowledge and adequate stakeholder engagement on water reuse was one of the factors that resulted in public rejection of the eThekwini Municipality water reuse project in 2012, rather than religious background. Though unsuccessful, the eThekwini Municipality water reuse project has become an important case study to investigate the reasons for negative public perceptions and factors influencing public opinions on water reuse. In terms of services provision, the scope within which water service institutions can provide non-potable reclaimed water services is not clear. This is because the Water Services Act only mandates municipalities to provide water that complies with SANS 241, and there are corresponding specific regulations for potable water tariffs. While agricultural water reuse is easily one of the applications that require less treatment, the complexity around legislation on the implementation of water reuse and provision of related services within the water service sector deters implementation (Graham, 2019).

- **Technical barriers**

Given, South Africa's history and investment in water reuse research and technology development, a wealth of literature and technology innovations exist to support implementation. However, the uptake and deployment of the generated knowledge and innovation derived products is lagging behind. For example, by now there is a general consensus that appropriate technology exists for treating almost any wastewater to any specification. However, a lack of public knowledge on treatment technology, lack of trust in implementation capacity of municipalities or lack technical skills within municipalities can jeopardise the success of the project. In particular, the poor performance of wastewater treatment works paints a negative picture with regards to the ability of municipalities to manage wastewater treatment. The 2014 Green Drop report showed that a majority of plants are in high risk (259 plants) and medium risk (218 plants), with 212 plants in critical risk and 135 plants in low risk space (DWS, 2014). The use of treated wastewater for direct potable applications can play an important role in meeting future municipal demands for water. However, if not treated properly, the reclaimed water can be a possible pathway for exposure to a high number of emerging contaminants of concern to human and environmental health. The available results from the Green Drop report (2014 version) indicate a poor performance in wastewater treatment, further creating public anxiety of the capacity of municipalities to treat wastewater to drinking water quality standards. In terms of implementing water reuse, selection of appropriate treatment technologies for adequate wastewater treatment to render the final water safe for use is critical. Apart from technology, availability of adequate human and laboratory capacity for specialised water quality analysis is equally important. Recent findings from a Water Research Commission-funded study showed that there are not enough South African laboratories that can perform routine water analyses on emerging contaminants (Swartz et al, 2018). Thus, in order to support water reuse implementation and ensure water safety, there has to be investments in human and laboratory capacity. The lack of water quality regulations for water reuse is another major hurdle in the gaining public trust on water reuse. Neither the South African Water Quality Guidelines nor SANS 241 (drinking water quality standard) adequately covers emerging contaminants in terms of the water quality requirements for different uses of reclaimed water.

- **Economic factors**

A lack of a clear understanding the costs, benefits and function (in terms of water reuse application) of water reuse is one of the key hinderances to the implementation of sustainable implementation of water reuse. While the municipal default is the supply of potable water, immense opportunities are lost through unserved non-potable water, due to lack of specific regulations. While the economic and environmental benefits of water reuse are widely documented, there is still a need for relevant economic regulatory interventions in order to attract municipal interest in water reuse. In addition, the current poor performance of wastewater treatment plants, which can be partly attributed to lack of cost recovery, is one of the many factors hindering significant private investment in water services (Naidoo et al 2016). Moreover, the prevailing high municipal debt due to non-payment of services is yet another disincentive, which discourages municipal investment in water reuse projects (Graham, 2019). To support implementation of water reuse in municipalities, issues of affordability and willingness to pay need to clear addressed. Therefore, unlocking the reuse potential within the services delivery environment requires an understanding of these barriers and based on these devise practical strategies to enable its implementation.

Recommendations for enabling the widescale adoption of water reclamation and reuse in South Africa

Already, a number of recommendations and related plans of action for increasing the water reuse potential in South Africa have been identified in the National Water Reuse Strategy (DWA, 2013) and recently in the National Water and Sanitation Master Plan (NW&SMP) (DWS, 2018). The need for the integration of circularity principles in national water resources and water services sector policy and legislation documents cannot be overstated. Therefore, in making a case for water reclamation and reuse in South Africa, the following aspects need to be considered:

- Clear policies and legislation enabling circularity, i.e. recovery of water and other products from wastewater, in the water sector
- Supporting implementation capacity by putting in place the necessary institutional and legislative support system to ensure financial sustainability of water reuse projects
- Improving cost recovery and performance of wastewater treatment works (WWTW) to restore trust in municipal capabilities and improve public perceptions on water reuse, and also attract private sector investment in water services
- Putting in place necessary measures for attracting and growing water quality skills for plant design, effluent quality monitoring and testing, as well as plant process control
- Improving the laboratory capacity, particularly, municipal scientific services facilities in order to support routine water quality testing for reclamation and reuse
- Strengthening research, development and innovation

These aspects are briefly discussed in the sub-sections below.

- **Creating an enabling legislative environment for water reuse**

While water reclamation and reuse is not the panacea for solving all the water scarcity problems in South Africa, as it is still a climate-dependent option, it has been identified as a low hanging fruit for addressing spatial water supply challenges faced by communities. Water reuse governance aspects, such as clear policies and regulatory frameworks, clear institutional arrangements and corresponding roles and responsibilities, financial support, active stakeholder participation and public involvement, play an important role in enabling the wider adoption of water reuse practices. The issue of a water reuse governance framework as a stimulus for the widescale adoption of water reclamation and reuse has been the subject of numerous global and national discussions and debates. This aspect is clearly highlighted in a sector discussion document on the implementation of the National Water Reuse Strategy (DWS, 2013). A policy brief document compiled from the 2017 World Water Week event on Balancing competing interests and opportunities for better wastewater governance (SEI et al., 2018), which South Africa participated in, highlights the need to adequately manage the different interests from a policy and practical perspective, and is emphatic on the role of legislation across all government levels in creating an enabling environment for water reclamation an reuse. The complexities in coordinating the implementation of water reuse across the different water sector institutions at local, provincial and national levels, requires establishment of implementation agencies, with clear roles and responsibilities, particularly on who has oversight and enforcement responsibility over all the partners involved.

With regards to legislation, the National Water Act needs to be amended in order to include regulations for alternative water sources such as wastewater, seawater and others. The lack of regulations related to use of wastewater as a resource creates uncertainty about licensing requirements and has been identified as a regulatory risk (Graham, 2019). Thus, it is necessary that policy and regulatory aspects enabling water reuse are addressed in order to facilitate safe and appropriate reclamation and reuse programs. There is a need of specific regulations to govern the provision of reclaimed water services, particularly non-potable water, as well as the water quality specifications for each. While the relevance of water reclamation and reuse in meeting the water supply demand and the need to urgently fast track its implementation across all sectors has been explicitly stated in a number of water policy documents in South Africa, the recent being the National Water and Sanitation Masterplan (NW&SMP), it is evident that the intended outcomes, in terms of actual increase in the number of well-planned and managed reuse schemes, will not be realised at the envisioned pace until the governance aspects of water reuse are addressed adequately.

- **Building skills and supporting project implementation capacity**

The slow pace in the implementation of water reuse within local government indicates a need for putting in place institutional and regulatory support mechanisms in order to assist municipalities from project inception to implementation. Going into the future, plans to establish a national water reuse programme to support the scaled implementation of water reuse in South Africa are at an advanced stage. The planned programme support office will be coordinated by the Development Bank of Southern Africa with the support of government and other stakeholders, and will provide project preparation support, including conducting feasibility studies and selection of the most economically viable contracting arrangements and water reuse options, and also provide a blended finance option for municipalities. This program will also play an important role in enabling project buy-in through stakeholder and consumer engagement. Ensuring continuous communications and engagement of stakeholders and customers is one of the key success factors in the development of water reuse schemes (Swartz et al., 2015; Slabbert and Green, 2019). Furthermore, such a program would play an important role in ensuring the financial sustainability of the project.

Apart from ensuring financial sustainability, supporting municipal implementation of water reuse is necessary in order to build the necessary capacity and skills required to tackle variations in wastewater quality (in terms of technology selection and performance optimisation), water reuse applications and water quality risk management needs. A recent analysis of available laboratory capacity for advanced water quality analysis, in the context of water reclamation and reuse, showed that there is a lack of sufficient laboratory able to handle routine water quality analysis for emerging contaminants in South Africa (Swartz et al., 2018). The recommendation from this study is the establishment of a network of laboratories capable of performing specialised water quality analyses (Swartz et al 2018). This network can also assist in the development and validation of standard operating procedures, training of municipal officials and exchange of scientific data and technical knowledge. Establishment of the South African Local Government Association (SALGA)-led Municipal Scientific Services network is a step is the right direction and can help realise this ambition. The Water Institute of South Africa, through the Water Reuse Division, also has a role to play in the exchange of knowledge and best practices on water reuse.

- **Development and implementation of communications and stakeholder engagement plan**

Apart from the mandates of national department, local government has an important role to play in creating an enabling environment for stakeholder and public participation in the implementation of water reuse. In this regard, clear municipal bylaws on communications and stakeholder participation on water reuse are key to strengthening water reuse governance and can provide opportunities for public education and participation in the implementation of water reuse (Muanda et al., 2017). The importance of involving stakeholders from planning to implementation and ensuring informed public acceptance of water reuse projects in South Africa is a hard lesson learnt. For example, due to a number of public objections, a direct water reuse plant planned for the City of eThekwini was halted in 2012 (Golder Associates Africa, 2012). As a result, many other municipalities have over the years shelved plans for direct water reuse in fear of the repeat of this situation. The importance of stakeholder and public relations on water reuse are well recognised in the National Strategy for Water Reuse. A need for taking into consideration public opinions on water reuse, and continuous implementation of a dedicated communications programme is highlighted. Stakeholder engagement, particularly, public participation in water supply planning and management is included as part of the DWS water reconciliation programme, municipal WSDP process and also identified as a prerequisite in the implementation of water reuse in the National Strategy for Water Reuse. Additionally, public participation is also a key element in the implementation of any project, as part of the Environmental Impact Assessment (EIA), a process legislated under the National Environment Management Act, 1998 (Act No. 107 of 1998). The scope of an EIA, under the auspices of the Department of Environment, Forestry and Fisheries is to mitigate and/or manage the impacts of new developments and activities that are considered to potentially impact on the right to an environment that is not harmful to health and well-being. In essence, the EIA complements stakeholder and public engagement on aspects related to the planning and implementation of water reuse.

An analysis of South African case studies on water reuse implementation, has shown that there is still limited public participation in large infrastructure-type of water projects. Partly, this has been attributed to a knowledge deficit on water and general environmental issues as indicated in the findings of a baseline study on public knowledge on water and related aspects (Slabbert and Green, 2020). This study also highlighted the need to continuously educate the South African public on water issues. In accordance with these findings, a framework document on developing and implementing for water reuse education and communications strategy as stated in the National Strategy for Water Reuse has been developed (Slabbert and Green, 2020). The authors recognised public water literacy as a prerequisite to ensuring an engaged public and sustainability of water reuse. The aspect of public education and engagement on water reuse is important for building public trust and confidence and ensuring informed public acceptance and buy-in for water reuse. Currently, a project aimed at revising the 1982 guidelines for planning and implementing water reclamation schemes is underway.

- **Financial and economic aspects**

Over the past decade, there have been numerous reports on the life cycle costs related to construction, operation and maintenance of water reuse plants in South Africa (Swarts et al., 2014;

Turner et al., 2015; Friedrich, Goga and Buckley, 2017). Through research, water reuse decision making tools for selection and costing of water reuse technologies, REUSEDM and REUSECOST, have been developed (Swartz et al., 2014). A study by Turner et al (2015) details the cost and operational aspects of municipal potable water reclamation plants. Based on this study, the 2014/15 figures for construction of water reuse plants ranged from R12 – 16 million per ML/day for direct potable reuse plants, and R 5-10 million per ML/day for indirect reuse plants. Operational and maintenance costs for ranged from R2-7 per m^3 of product water. Considering the fact that most of these plants were commissioned as an emergency option, with sufficient planning the capital and operational costs can be lower. The financial requirements for implementing water reclamation and reuse projects will vary significantly based on the type of desired wate reuse application, where the cost will increase with the degree of treatment required. Generally, a life cycle cost (LCC) analysis is needed to evaluate conditions under which water reclamation and reuse programs would be cost effective.

With regards to funding, so far implementation through Public Private Partnerships (PPP) or similar partnerships has been shown to be ideal. Public-private partnerships can help diversify risk, promote high-quality outputs and can result in more economically efficient and reliable service delivery through the pursuit of profit maximization. Current successful examples include the Durban Water Recycling plant. Graham (2019) notes the need to review current legislation in order to promote private sector investment in water services. With regards to the potential economic benefits of water reuse, implementation of reuse projects alleviates the pressure on surface and groundwater resources and contributes to environmental sustainability and creation of job opportunities, sustainable livelihoods, concepts which fit within the circular economy objectives. Wastewater is a resource and the circular economy framework for wastewater management promotes the recovery of valuable products, such as energy, nutrients and scarce water resources. Widescale adoption of water reuse practices is also likely to stimulate innovation, resulting in the creation of new local water entrepreneurs and creating employment opportunities as envisioned in the Department of Trade and Industry's Industrial Policy Action Plan. However, realising the economic benefit of resource recovery practices during water reclamation requires alignment and systematic changes in the whole water and sanitation value chain and related legislation.

- **Regulating use of appropriate technology and water quality risk management**

If not adequately treated, reclaimed water can be a pathway to exposure to a large variation of potential chemical and biological water quality hazards and risks. Thus, water should only be reused in a safe and sustainable manner, by following a risk-based approach (water safety planning). This involves comprehensively determining all the water quality risks from source to point of use, and deploying the necessary (multi) treatment barriers and other requirements for ensuring safe use and protection of the environment. While risk-based regulatory framework has been adopted for drinking water (Blue Drop) and wastewater (Green Drop) quality, there is no specific regulation for reclamation plants and water quality requirements for different uses. A water reclamation drop-type of a regulatory framework will need to be developed to address the different use categories. Already a wealth of information exists on water reuse guidelines, such as the World Health Organisation's guidelines for safe use of wastewater, excreta and greywater (WHO, 2006), as well as the recent guidelines for potable water reuse issued by the WHO (WHO, 2017) and the USEPA (USEPA, 2012). Additionally, considerable case study work has also been done on South Africa potable water reclamation plants including proposed water quality guidelines for drinking water (Swartz et al., 2015). Though with a focus on surface water resources, the South African Water Quality Guidelines can also be consulted and used as basis for the development of water quality regulations for other uses. In terms of water quality risk assessment, there is ongoing research and innovation focusing on the development of risk and toxicity assessment approaches for ensuring water safety. In summary, there is a need to develop a legislative instrument on minimum water quality requirements for specific uses of reused water. Moreover, ensuring adequate and reliable operation of water reuse systems and appropriate regulatory enforcement are equally important.

- **Strengthening uptake of research, development and innovation**

Being a water scarce country, investigations on the possible reuse of treated wastewater for potable and non-potable applications in South Africa have been done since the early 1950s. Since then, South Africa has remained at the forefront, in terms of, water reclamation and reuse technology development and knowledge generation. On the contrary, widescale adoption of the practice has been happening at a much slower pace. Work done in collaboration with the Council of Scientific and Industrial Research (CSIR) of South Africa in the early 1960s contributed to the commissioning of the Windhoek direct potable reuse plant in 1968, which is regarded as the world's first. In South Africa, this work was used to support the commissioning of the very first direct water reuse demonstration plant, the CSIR Stander demo plant (Pretoria, South Arica), with a design capacity 4.5 ML/d in 1970 (Grobicki and Cohen 1999). Since then, South Africa has remained at the forefront of water related research and technology. The importance and role of research, development and innovation in supporting the move towards integrated water resources planning and management is clearly stated in Chapter 14 of the NWRS II. The country's ten year plan for water research as stipulated in the NWRS II is contained in the National Water RDI Roadmap, a partnership initiative between the Department of Science and Technology (DST), Department of Water and Sanitation (DWS) and the Water Research Commission (WRC). This plan identifies seven (7) research priorities; (i) unlocking alternative sources of water, (ii) governance, planning and management of supply, (ii) improving adequacy and performance of infrastructure (built and ecological), (iv) financially sustainable "business" approaches for improving operational performance, (v) governance, planning and management of demand, (vi) reducing losses and increasing efficiency of productive use, and (vi) improving monitoring and metering (DST, DWS and WRC, 2015).

The importance of RDI in supporting the implementation and scaling-up of water reuse is not a straightforward process. From the South African experience, it is clear that without sufficient uptake, the available research and innovations are not likely to result in the desired scale of implementation. Ensuring uptake of research and innovations into operations requires institutional re-organisation into an innovation ecosystem. Granstrand and Holgersson (2020) define this concept as the evolving set of actors, activities, and artifacts, and the institutions and relations, including complementary and substitute relations that are important for the innovative performance of an actor or a population of actors. The Water RDI roadmap recognises the importance of technology legitimation through demonstration and validation as key to the adoption of new knowledge or technology innovations into existing institutional structures or practices. The Water Technologies Demonstration (WADER) programme plays an important role in this aspect. The demonstration of concepts, ideas and innovation in real municipal settings, not only speeds up the uptake, but also plays an important role in building the necessary skills required for engaging in that specific technology. In this regard, there is a need to strengthen partnerships between the WADER programme, innovators and water service institutions. Such partnerships will also help realise the country's goals for localising the water industry and bolstering water entrepreneurship, as stated in the Department of Trade and Industry's Industrial Policy Action Plan 2017/18 to 2019/20 (DTI, 2017).

Conclusion

Despite a number of challenges, there is an indication that the implementation of water reclamation and reuse within municipalities is likely to increase in the coming years. Currently, water reuse has been afforded a priority status in most coastal municipal cities. Strengthening water and sanitation management and creating an enabling environment in the water sector, as envisioned in the NW&SMP will undoubtedly assist in addressing most of the challenges highlighted above. In line, with the strategic action of the NW&SMP, the following needs to be considered for the widescale adoption of water reuse in municipalities:

- Clear policies and legislation enabling circularity, i.e. recovery of water and other products from wastewater, in the water sector
- Supporting implementation capacity by putting in place the necessary institutional and legislative support system to ensure financial sustainability of water reuse projects. The Development Bank of Southern Africa-led initiative is an important programme to learn from and strengthen going into the future.
- Proving training support to local government in order to improve cost recovery and performance of wastewater treatment works (WWTW) to restore trust in municipal capabilities and improve public perceptions on water reuse, and also attract private sector investment in water services
- Developing and implementing a drop-type regulation for water reclamation plants in order to regulate performance, including water quality aspects.
- Putting in place necessary measures for attracting and growing water quality skills for plant design, effluent quality monitoring and testing, as well as plant process control
- Improving the laboratory capacity, particularly, municipal scientific services facilities in order to support routine water quality testing for reclamation and reuse
- Strengthening research, development and innovation

References

Asano T, Burton F, Leverenz H, Tsuchihashi R and Tchobanoglous G (2007) Water Reuse: Issues, Technologies, and Applications. 2007 Metcalf & Eddy, Inc.

Bailey AK and Pitman WV (2017) Water resources of South Africa 2012 study (WR2012). WR2012 Executive Summary. WRC Report No. TT 683/16.

Bugan RDH, Jovanovic N, Israel S, Tredoux G, Genthe B, Steyn M, Allpass D, Bishop R and Marinus V (2016) Four decades of water recycling in Atlantis (Western Cape, South Africa): Past, present and future. Water SA 42, 4.

Burke J (2007) Integrated Water Resources Management Plan Guidelines for Local Authorities. WRC Report No TT304/07. Water Research Commission, Pretoria, South Africa.

City of Cape Town (2020) Cape Town's Water Strategy. Our shared water future. Launched in February 2020. https://resource.capetown.gov.za/documentcentre/Documents/City%20strategies,%20plans%20and%20frameworks/Cape%20Town%20Water%20Strategy.pdf

DEA (Department of Environmental Affairs) (2014) National Guideline for the Discharge of Effluent from Land-based Sources into the Coastal Environment. https://www.environment.gov.za/sites/default/files/legislations/nationalguideline_landbasedinfluent_dischargecoastal_0.pdf

DEFF (Department of Environment, Forestry and Fisheries (2019) Draft National Waste Management Strategy. https://www.environment.gov.za/mediarelease/revisedwastestrategy_forpubliccomment

DST (Department of Science and Technology), WRC (Water Research Commission) and DWS (Department of Water and Sanitation) (2015) South Africa's Water Research, Development, and Innovation (RDI) Roadmap: 2015-2025. WRC Report No. 2305/1/15.

DST (Department of Science and Technology) (2019) White Paper on Science, Technology and Innovation. https://www.dst.gov.za/index.php/legal-statutory/white-papers/2775-white-paper-on-science-technology-and-innovation

DWA (Department of Water Affairs) (2013) National Water Resources Strategy. Water for an equitable and sustainable future. Second edition. June 2013. http://www.dwa.gov.za/documents/Other/Strategic%20Plan/NWRS2-Final-email-version.pdf

DWAF (Department of Water Affairs and Forestry) (2004) National Water Resources Strategy. Our blueprint for survival. First Edition. September 2004.

DWS (Department of Water and Sanitation, South Africa) (2014) Green Drop progress report of 2014. 22p. https://www.greencape.co.za/assets/Sector-files/water/Department-of-Water-and-Sanitation-DWS/DWS-2014-Green-Drop-progress-report-introduction-2016.pdf

DWS (Department of Water and Sanitation) (2018) National Water and Sanitation Master Plan Volume 1: Call to Action. https://www.gov.za/sites/default/files/gcis_document/201911/national-water-and-sanitation-master-plandf.pdf

Friedrich E, Goga T and Buckley C (2017) A comparative life cycle assessment for the provision of potable water from alternative sources in South Africa. WRC Report No. TT 731/17.

Golder Associates Africa (2012) Environmental Impact Assessment (EIA) for the proposed water reclamation scheme - Draft Environmental Impact Assessment. Golder Associates Africa, Johannesburg.

Graham N (2019) Barriers and opportunities for water reuse PPPs in South Africa. Draft paper written for the European Union-South Africa Partners for Growth. https://www.euchamber.co.za/wp-content/uploads/2020/03/Barriers-to-water-reuse-Final-Report-20200113.pdf

Granstrand O and Holgersson M (2020) Innovation ecosystems: A conceptual review and a new definition. Technovation 90–91.

Grobicki A and Cohen B (1999) Water reclamation for direct reuse in urban and industrial applications in South Africa and its projected impact upon water demand. WRC Research Report KV 118/99.

IWA (International Water Association) (2018) Wastewater report 2018. The reuse opportunity. https://reliefweb.int/sites/reliefweb.int/files/resources/OFID%20Wastewater%20report%202018%20screen.pdf

IPCC (Intergovernmental Panel on Climate Change) (2018) Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty World Meteorological Organization, Geneva, Switzerland.

Mekonnen MM and Hoekstra AY (2016) Four billion people facing severe water scarcity. Science Advances 12, 2.

Muanda C, Cousins D, Lagardien A, Owen G and Goldin J (2017) Direct reclamation of municipal wastewater for drinking purposes. Volume 2: Investigation into institutional and social factors influencing public acceptance of reclaimed water for potable uses in South Africa. WRC Project No. TT 734/17.

Naidoo N, Pearce D, Visser W, Crafford J, Maila D and Harris K (2016) Implementation of effective wastewater charges by municipalities in South Africa: an investigation into the barriers and enablers. WRC Report No. TT 673/16.

SEI (Stockholm Environment Institute), GIZ, UNDP-SIWI Water Governance Facility, CEPT University, Water Research Commission of South Africa and Sustainable Sanitation Alliance (2018). Wastewater Governance: Balancing Different Interests. Policy brief. Stockholm International Water Institute (SIWI), Stockholm. https://www.sei.org/publications/wastewater-governance-balancing-interests/

Slabbert S and Green N (2019) Public knowledge of water re-use and other water related aspects. WRC Report No. TT 807/19.

Slabbert S and Green N (2020) A communication strategy for water re-use in South Africa. Volume II: Communication strategy and toolkit development. WRC Report No. 2805.

Swartz CD, Coomans CJ, Müller HP, du Plessis JA and Kamish (2014) Decision-support model for the selection and costing of direct potable reuse systems from municipal wastewater. WRC Report No. 2119/1/14.

Swartz CD, Genthe B, Menge JG, Coomans CJ and Offringa G (2015) Direct reclamation of municipal wastewater for drinking purposes. Volume 1: Guidance on Monitoring, Management and Communication of Water Quality. WRC Report No. TT 641/15.

Swartz CD, Genthe B, Chanier J, Petrik LF, Tijani JG, Adeleye A, Coomans CJ, Ohlin A, Falk D and Menge JG (2018) Emerging contaminants in wastewater treated for direct potable reuse: The human health risk priorities in South Africa. WRC Report TT 742/1/18.

Tayob AI, Deedat H and Patel AR (2015) Islamic jurisprudence and conditions for acceptability of reclamation of wastewater for potable use by muslim users. WRC Report No. 2360/1/15.

Thebo AL, Drechsel P, Lambin EF and Nelson KL (2017) A global, spatially-explicit assessment of irrigated croplands influenced by urban wastewater flows. Environmental Research Letters 12, 074008.

Thompson I, Riemann K and Hay R (2015) All towns water reconciliation strategies in the western and eastern cape – achievements and challenges. https://www.imesa.org.za/wp-content/uploads/2015/11/Paper-12-All-towns-water-recon-strategies-in-the-Western-Eastern-Cape-Isa-Thompson.pdf

Tortajada C (2020) Contributions of recycled wastewater to clean water and sanitation Sustainable Development Goals. *npj Clean Water* 3, 22.

Turner KN , Naidoo K, Theron JG and Broodryk J (2015) Investigation into the cost and operation of Southern African desalination and water reuse plants. WRC Report No TT 638/15.

UN (United Nations) Environment (2018). Progress on integrated water resources management. Global baseline for SDG 6 Indicator 6.5.1: degree of IWRM implementation.
https://www.unwater.org/publications/progress-on-integrated-water-resources-management-651/
USEPA (United States Environment Protection Agency) (2012) Guidelines for Water Reuse.
https://www.epa.gov/sites/production/files/2019-08/documents/2012-guidelines-water-reuse.pdf
van Koppen B and Schreiner B (2014) Moving beyond integrated water resource management: developmental water management in South Africa. International Journal of Water Resources Development, 30:3, 543-558.
van Niekerk AM and Schneider B (2013) Implementation plan for direct and indirect water re-use for domestic purposes – Sector Discussion Document. WRC Report No. KV 320/13.
WHO (World Health Organisation) (2006) WHO guidelines for the safe use of wastewater, excreta and greywater / World Health Organization.
https://apps.who.int/iris/bitstream/handle/10665/78265/9241546824_eng.pdf;jsessionid=D9B10B8110A07B6EAC79DFB9B800E8EB?sequence=1
WHO (World Health Organisation) (2017) Potable reuse: Guidance for producing safe drinking-water.
https://www.who.int/water_sanitation_health/publications/potable-reuse-guidelines/en/
WWF-SA (2017) Scenarios for the Future of Water in South Africa.
http://awsassets.wwf.org.za/downloads/wwf_scenarios_for_the_future_of_water_in_south_africa_v7_6_pf_1.pdf

Annexure 1 - Terminology and definitions in water reclamation and reuse (adapted from Swartz et al (2015))

- **Wastewater** - Wastewater is any water that is derived from a variety of possible uses of the water, and typically contains residual pollutants associated with the use of the water.
- **Return flows** - Return flows are treated or untreated wastewater that is discharged to a natural surface water or groundwater body after use.
- **Water reuse** - Water reuse comprises the utilisation of wastewater or effluent from a variety of sources (e.g. domestic wastewater, effluent from various industries, storm water, mine effluent) for a new or different beneficial application, such as for drinking purposes, industrial use or irrigation.
- **Potable reuse** - Potable reuse involves the reuse of wastewater for drinking purposes after it has been extensively treated by a number of treatment processes to produce water that is safe for human consumption and other human use.
- **Non-potable reuse** - Non-potable reuse is the reuse of treated or untreated wastewater for purposes other than for drinking water or potable purposes, such as industrial purposes or irrigation.
- **Direct reuse** - Direct reuse involves the reuse of treated or untreated wastewater or effluent by direct transfer from the site where it was produced, to the site of the new or different beneficial application.
- **Indirect reuse** - Indirect reuse comprises the reuse of treated or untreated wastewater from a surface water or groundwater body where it was discharged to with the intention of reuse, before being abstracted for reuse at a new or different site of beneficial application.
- **Planned reuse (intentional reuse)** - Planned reuse is the reuse of treated or untreated wastewater as part of a planned project, and is therefore always performed intentionally and consciously for a specific application(s).
- **Unplanned reuse (incidental reuse or de facto reuse)** - Unplanned reuse is the reuse of treated or untreated wastewater after it has been discharged as return flow into a surface water or groundwater body without the intention of reuse, and from which it is then abstracted for a variety of applications