MUNICIPAL BRIEF

Smart water systems

Applicable across all of South Africa

This brief is intended for municipalities that are interested in exploring smart systems for improved water management.

Main insight

Smart systems are sensor-based networks that enable the automatic collection, mining and analysis of data for intelligent, real time decision making and faster reaction times. Several municipalities have implemented smart systems to improve their water management, including:

- *Cape Agulhas Municipality* has implemented a smart groundwater management system that they anticipate will save them R1.4 million/yr in transport and labour costs, from an initial investment of R2.7 million.
- *Saldanha Bay Municipality* has already rolled out ~5 600 residential ultrasonic smart water meters. Smart pressure management zoning in a high leakage bulk distribution area has led to R6.3 million/year being saved through reduced bursts.
- *Bergrivier Municipality* installed ~350 residential smart water meters, resulting in revenue enhancement and accurate billing. The households benefit from having access to an app that allows them to monitor their water usage, detect leaks and log faults, leading to improved customer service.

The implementation of smart systems can result in a number of benefits to both a municipality and its customers. However, if inappropriately applied, smart systems can lead to greater inefficiencies. It is therefore important that municipalities first carefully consider their context and resources before deciding to procure a smart system.

Context

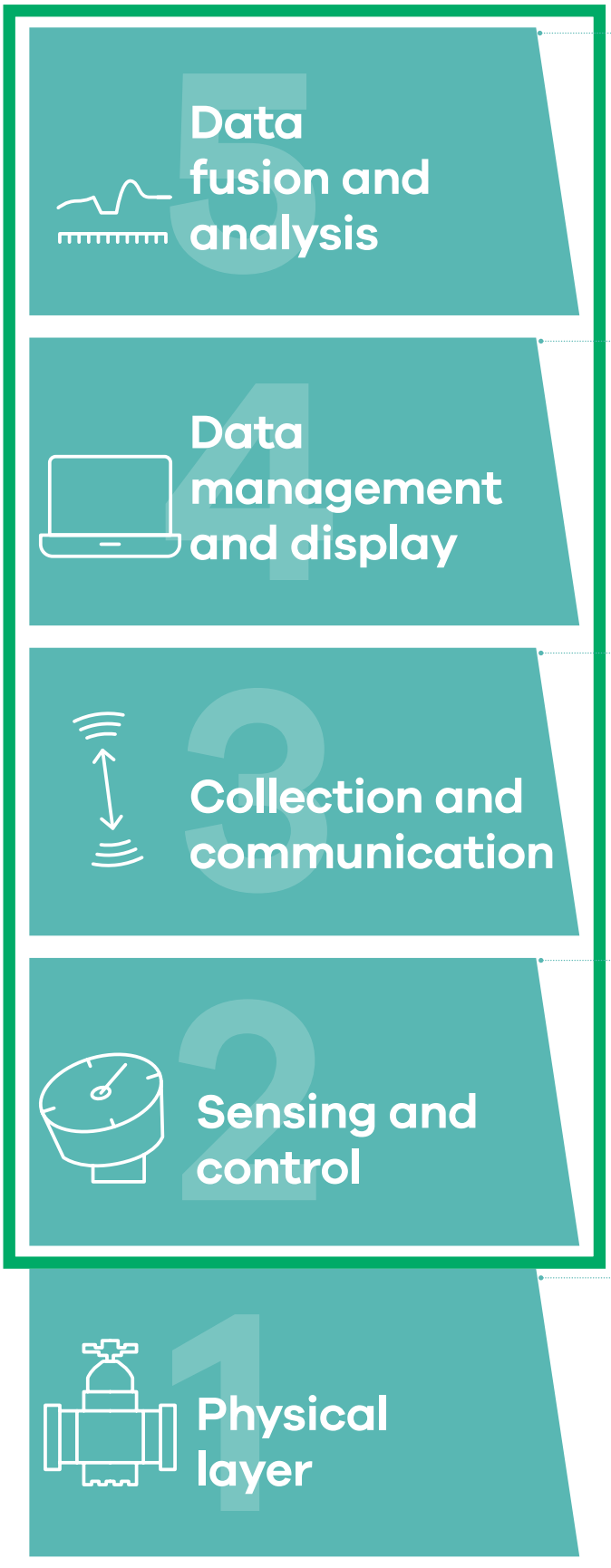
This brief is intended for municipalities that are interested in exploring smart systems for improved water management, and covers the following:

- What are smart water systems?
- Case study examples of municipal smart water systems.
- When do smart systems make sense?
- Spotlight on smart water metering: Costs and benefits.
- Useful resources for funding and support.

What are smart water systems?

Smart systems are sensor-based networks that enable the automatic collection, mining and analysis of data for intelligent real-time decision making and faster reaction times. Smart water systems, or networks, consist of multiple layers, as shown in **Figure 1**.

Figure 1: A layered view of smart water networks (SWAN) (read from bottom to top)



5 The **data fusion and analysis** layer produces processed knowledge from the raw input data, e.g. hydraulic modelling systems, network infrastructure monitoring, smart pressure management, smart (not fixed feedback) pumping or energy optimisation systems, and Decision Support Systems.

4 The **data management and display** layer is where data from different sources comes together and may be used by operators. Operator commands or instructions from higher-level systems are also interpreted into device settings (e.g. switching off pumps). Examples of components that might fall in this layer include dashboard applications provided with Supervisory Control and Data Acquisition (SCADA) systems, Geographic Information System (GIS) or network schematic visualisation tools, control room systems with simple alert rules, graphical control interfaces.

3 In the **collection and communications** layer data is collected, transferred and stored. There are several different communication technologies including wireless M-Bus (which can be used for drive-by data collection or via a fixed network), LoRaWAN (a low powered, radio based network protocol), Sigfox (a proprietary network that users can pay a subscription fee to access), narrow band internet of things (NB-IoT, a new Global system for Mobile (GSM) technology using existing mobile networks) and other fixed cable, radio, cellular and Wi-Fi technologies.

2 The **sensing and control** layer includes smart sensors that can measure different water-related parameters (e.g. smart water meters to measure flow/consumption, smart level meters to measure the levels of water in dams, reservoirs, boreholes etc., smart sensors to measure water quality parameters, etc.) as well as devices that can control the network remotely, e.g. remote-controllable pumps, valves, and pressure-reducers.

1 The **physical layer** includes the physical components of a water management network, e.g. pipes, pumps, valves, reservoirs etc. that typically perform mechanical, hydraulic or chemical functions.

For more information, visit The Smart Water Networks (SWAN) Forum's website

Case study examples of municipal smart water systems

Cape Agulhas Municipality

Cape Agulhas Municipality (CAM) has implemented smart systems to improve their groundwater monitoring and management system and reduce non-revenue water. CAM first set up a municipal-wide communication network using LoRaWAN technology. Suiderstrand (a small coastal town) was then chosen to pilot the smart groundwater management system. Piezometer tubes and level sensors were installed in the reservoirs to provide real-time information on the reservoir water levels. The reservoir pumps were fitted with variable speed drives (VSDs) and downstream flow meters, to monitor and control the flow of water remotely based on inputs, such as the reservoir level or time of day. The boreholes were also fitted with piezometers and the borehole pumps were fitted with VSDs and downstream flow meters.

This smart system has significantly reduced the transport and labour costs associated with performing the manual readings of their bulk system. Based on the benefits observed to date, CAM anticipate total annual savings of R1.4 million compared to an initial investment of R2.7 million resulting in a project payback period of 24 months on their initial capital outlay. The smart system also enables the municipality to have a holistic, real-time view of their resources, making it easier to make informed decisions and respond quicker. For more information on the CAM smart water programme, please view this case study.

Saldanha Bay Municipality

Motivated by the need to improve billing accuracy and reduce water demand and meter reading costs, Saldanha Bay Municipality decided to pilot the use of residential smart water meters in the town of Vredenburg. By the end of 2021 around 5 600 ultrasonic smart water meters had been installed at residential properties. A concentrator has also been installed, which automatically collects and transmits readings from ~1 500 of the meters to the central systems via a cellular (GSM) or fibre network.

Gavin Williams, the Senior Manager of Water and Sanitation, describes the benefits observed to date: *"With the new meters and the remote reading system, we are able to provide better service to our customers. The solution also makes it possible to get real-time data of the consumption and water balances, which gives us valuable information about our distribution network. We have already seen massive improvements since we implemented the smart metering solution."*

The municipality plans to continue the roll out of the residential smart water meters. Starting in December 2021, the municipality is also installing a fibre network in three of their towns. Each household will have access to a fibre connection, as well as an app that will provide them with the water consumption data from their smart meter, and other relevant data.

Saldanha Bay Municipality has also implemented smart pressure management zoning in one of their high leakage bulk distribution areas, supplying ~2 500 consumers. One district metering area and two pressure management zones were established with 150mm pressure reducing valves. As a result of these interventions, burst frequency reduced from 50.4 to 7.25 bursts per month, leading to annual savings of R6.3million (R12 000 per burst).

Bergrivier Municipality

In order to reduce non-revenue water, Bergrivier Municipality piloted residential smart water metering in Velddrif, where 350 meters were installed. The meters communicate the data via the Sigfox network, to which the municipality pays a monthly subscription. In many of these households, the existing mechanical meters had been located within the properties, where the meter readers had been unable to access and read them. As a result, household consumption had historically either been estimated or billed as zero consumption. The new smart meters, which can be read remotely, have therefore resulted in revenue enhancement for the municipality, as well as reducing human error (more accurate billing). The households benefit from having access to an app that allows them to check their water usage, receive alerts if a leak is detected, and log faults, leading to improved customer service.

The municipality intends to continue rolling out smart water meters to their residential customers, with R1 million budgeted for 2021/21 for the installation of a further 350-400 smart meters. To avoid any meter reading job losses, the municipality plans to redirect these resources towards activities, such as meter maintenance and new connections.

When do smart systems make sense?

As is clear from the case study examples, the implementation of smart systems can result in a number of benefits to both a municipality and its customers. However, if inappropriately applied, smart systems can lead to greater inefficiencies, as is captured by this famous quote from Bill Gates:

> *"The first rule of any technology used in a business is that automation applied to an efficient operation will magnify the efficiency. The second is that automation applied to an inefficient operation will magnify the inefficiency."*
>
> **Bill Gates, 1995**

It is therefore important that municipalities carefully consider their context before deciding to procure smart systems. Below is a checklist that covers some of the key questions that should be considered before proceeding with smart systems.

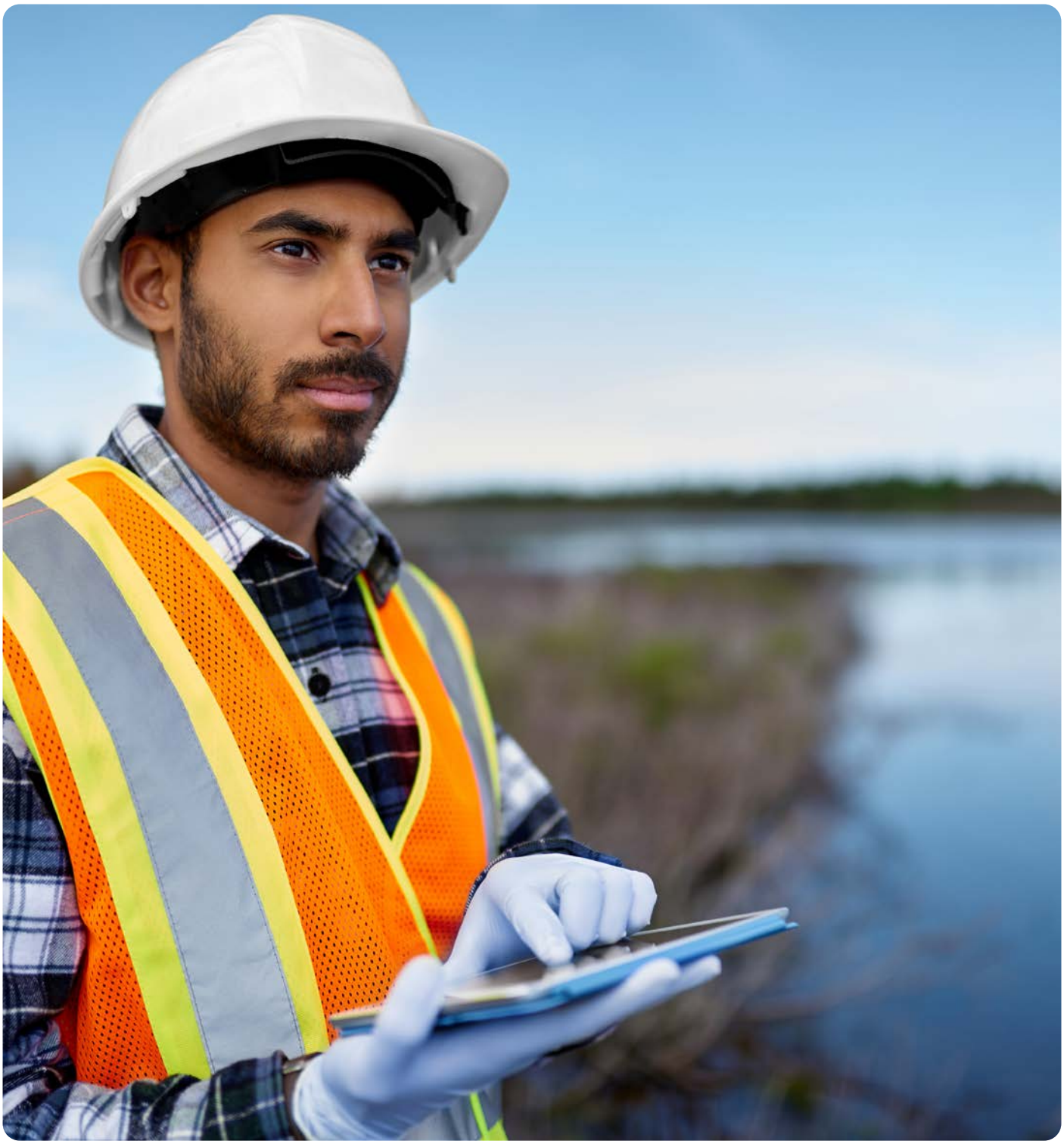


Table 1: Checklist of questions for municipalities considering smart water systems

KEY QUESTIONS	DETAIL
Do you have a strong IT department within your municipality?	As smart systems involve a number of different technologies, it is critical that any municipality that intends to implement these systems has a good IT department, where the core skills will sit. Consultants can assist in the short-term, but in order to make smart systems sustainable in the long-term, in-house skills are needed.
How much data do you need?	Typically, only a small amount of data is needed to make good decisions, and municipalities may be tempted to implement systems that generate significantly more data than is needed. It is important for municipalities to understand what data they need, as well as the type of systems required to analyse the data. In order to do this, it is suggested that municipalities first undertake a pen and paper exercise, mapping out their current business processes, decision-making processes and what data is currently used. This exercise will help municipalities establish what data is needed, and whether a smart system will actually help improve their decision-making and response times.
What is the 'right' data?	
What systems do you need to analyse the data?	
How do you make decisions?	
What problem does it solve?	In order to ensure success, smart systems should not be implemented for the sake of going 'smart', but should rather be implemented to address a specific problem, e.g. inaccurate billing, poor customer service, high transport costs of manual bulk system readings.
How prepared is your municipality for change?	People are critical to the success and adoption of smart systems. A shift in approach is required, and it is important that staff are open to change, and that a change management process is put in place to properly equip staff. Smart systems may result in the need to hire new staff with different skills, or to reassign or replace people. In smaller, rural municipalities, the training of staff may lead to high staff turnovers, as the training may open up new career opportunities in technology.
Do you have the right people to deal with the smart systems?	
Do you have the materials and infrastructure to act on the data	Automatic data and the ability to make improved decisions is not useful if there are insufficient resources, materials or infrastructure to then respond. It is suggested that, before investing in smart systems, municipalities consider what resources they have to act on the data received (e.g. are there enough vehicles/staff to respond to leak detection alarms in bulk reticulation?)
Have you assessed relevant policies, frameworks, guidelines and legislation?	Prior to the implementation of any technology, it is recommended that municipalities assess policies (e.g. internal IT policies), frameworks, guidelines and legislation (e.g. the new Protection of Personal Information Act (POPIA)) that are relevant in the context of their municipality and the wider governance structures.
Are you aware that smart systems take time to implement?	Smart systems never bring fast change, they bring long-term, sustainable change that require patience. There are no quick solutions for smart systems, and there are often unintended or unexpected consequences.
Are you willing to budget a recurring cost for smart systems?	Smart systems are long-term, recurring costs on a municipal budget, and are not a once off cost.
Are there opportunities to leverage communications infrastructure that could be utilised for multiple purposes?	Establishing a smart communications network can be expensive, but if this infrastructure is adaptable, it could be utilised by multiple departments and for a variety of purposes. For example, small-scale embedded generators who wish to feed back into the grid, smart lighting, public access WiFi points etc. Consider the use case across the municipality to see if the business case can be made more attractive with multiple beneficiaries.
Have you engaged with other municipalities?	Many municipalities across South Africa are exploring smart systems and there are opportunities to learn from their experiences. *If you would like to be connected to another municipality, please contact GreenCape (water@greencape.co.za)*

Spotlight on smart water metering: Costs and benefits

Smart water metering, either for customers (e.g. residential, commercial and/or industrial) or for bulk water infrastructure, is a growing topic of interest for many SA municipalities. It is essentially the online, near real-time metering of the flow (or consumption) of water through pipes (physical layer) using smart water meters (sensing and control layer) to gather data, which is then transmitted via communication technologies to systems that display, analyse and manage the data (see **Figure 1**). Certain types of smart meters can also be used to control the flow of water, such as pre-paid meters.

As indicated in **Table 1**, in order to be successful, smart water systems should address a problem. In the case of smart water metering, such problems can include:

1. **Non-revenue water:** Near real-time monitoring can be used to better understand the municipal water balance, detect leaks in bulk water pipelines (e.g. Cape Agulhas Municipality) or enable meter reading of inaccessible meters (e.g. Bergrivier Municipality).
2. **Billing inaccuracies:** Ultrasonic smart meters have no moving parts and typically maintain their accuracy over their lifetime. In contrast, conventional mechanical meters can drift (i.e. depending on the quality of the water and meter type, they can under-report, especially as they age, leading to a loss of revenue, or they can over-report (e.g. due to the presence of air in the pipes)).
3. **Pump maintenance challenges:** Monitoring of down-stream flow can help predict pump performance to better plan in advance for replacements (e.g. Cape Agulhas Municipality).
4. **Water scarcity or poor customer service:** Through apps, customers can have better access to information on their usage, can more readily detect onsite leaks and can report faults (e.g. Bergrivier Municipality).

How does the cost of smart water meters compare to conventional mechanical meters?

Residential ultrasonic smart meters (those that collect data only, without any flow control functions) can cost ~R2 000 each excluding installation, compared to R300 – R500 each for conventional mechanical meters. Installation costs for smart meters are similar to those of conventional meters.

Despite their higher upfront cost, smart meter manufacturers claim that the batteries can last up to 16 years, depending on the frequency of data readings and transmissions, the data communication technology, and the ambient temperature when the readings are transmitted. As smart meters are a relatively new technology to South Africa this lifespan still needs to be verified in the field. The batteries of smart prepaid meters have shorter lifespans (reportedly up to 3-8 years) and therefore need to be located in an accessible position. Conventional mechanical meters typically need to be replaced every 7-10 years.

If it assumed that smart meters only need to be replaced every 16 years and mechanical meters every 8 years, and that mechanical meters drift by 2% per year, the net present value of investing in residential smart meters instead of mechanical meters is shown in **Table 2**. The analysis suggests that (for the given assumptions – see **Table 2** below) after 16 years the costs of smart metering are very similar to the cost of conventional metering (i.e. the municipality saves a total of R56 over the 16 years for each smart meter it installs instead of a mechanical meter). The business case will however vary from municipality to municipality, depending on the context, as will the non-financial benefits of smart metering (e.g. improved customer service etc.).

Table 2: Estimated net present value over 16 years of a municipality investing in a residential smart water meter instead of a conventional mechanical meter

PARAMETER PER HOUSEHOLD (HH)	TOTAL VALUE OVER 16 YEARS
Cost of smart meter (per HH)	R2 050 in Year 0
Avoided cost of conventional meters (per HH)	R400 in Year 0, R400 + R725 (installation) in Year 9
Net present Value (NPV) of installing a smart meter instead of a mechanical meter in one household	R56

Assumptions:

- Average household water use: 12kl/month (remains constant).
- Conventional meter drift: 2% p.a. (Year 1: 4% over-registering; by Year 8: 10% under-registering).
- Ultrasonic meter battery life: 16 years; Mechanical meter life: 8 years.
- Water tariff (6-20kl): R14.90/kl in Year 0 (Saldanha Bay Municipality).
- Annual water tariff increase: 5%.
- Discount rate: 5%.
- **Excludes data communication /management /display /analysis costs (as these can be shared with other smart sensing technologies).**
- **Excludes transport and labour savings from avoided manual water readings.**
- **Excludes any other direct/indirect savings/revenue benefits, e.g. increased revenue from zero billed, inaccessible meters.**

Useful resources for funding and support

1. **SIDAFF:** In the Western Cape, the Provincial Government is providing project preparation support for catalytic municipal infrastructure projects through the Sustainable Infrastructure Development and Financial Facility (SIDAFF) Programme. The Programme, funded by the French Development Agency (AFD), aims to increase bankable municipalities' access to loan financing for infrastructure projects in order to address the decreasing availability of grant funding. Contact the WCG Department of Local Government or GreenCape (water@greencape.co.za) for further information.

2. **CIP grant:** The Department of Trade, Industry and Investment (dtic) has re-vamped its Critical Infrastructure Programme (CIP) which is a cash grant of between 10% and 30% on qualifying infrastructure, capped at R50 million. The grant is now open to a larger range of infrastructure projects, including private water and sanitation infrastructure and agri-processing sector infrastructure (and Municipal projects, including project preparation funding up to 100%), inter alia. Interested parties can contact the dtic, who have a team that helps with incentive application admin for free. Consult the dtic website and the Amended Guidelines for more details on qualifying projects and eligibility requirements.

3. **DBSA's Non Revenue Water Programme:** The Development Bank of Southern Africa (DBSA) is in the process of establishing a centralised national office to help municipalities prepare and implement non-revenue water (NRW) projects (including those that reduce leaks or losses, increase revenue or improve billing accuracy). The programme will also design specific funding solutions that will help municipalities finance the projects. For example, performance-based contracts, developed by the World Bank Group and others, have been successfully used to finance non-revenue water projects internationally, and will be designed as a standard financing option as part of the programme. For more information, contact Johann Lübbe (johannl@dbsa.org), Disruption Specialist, DBSA or Konstant Bruinette (konstantb@dbsa.org), Senior Deal Originator, DBSA.

4. **Standard performance-based contacts for NRW reduction:** The World Bank has developed a number of publications to help water utilities reduce non-revenue water via performance-based contracts (PBC). These include general information on PBCs (accessible here), standard procurement documents and PBC for NRW reduction (accessible here), and guidelines for the use of the standard PBC documents (accessible here).

5. **WADER:** The Department of Science and Innovation (DSI), in collaboration with the Water Research Commission (WRC), has established the Water Technologies Demonstration (WADER) Programme. The programme aims to support the development of emerging, pre-commercial or newly commercialised innovative water and sanitation technologies. Municipalities that are interested in identifying or piloting innovative technologies, including smart systems, can reach out to WADER for support. In addition, WADER also runs the Young Engineers 'Changemakers' Programme, which is a one-year training programme for young South African municipal engineers that aims to give them the necessary skills to drive innovation in municipalities. For further information, contact wader@wrc.org.za.

Dam level sensing at Cape Agulhas Municipality

Borehole depth and flow rate sensing at Cape Agulhas Municipality

Further information

For further information and support on any of the content provided here, or if you would like to be out in contact with another municipality that is exploring smart systems, please contact GreenCape's water sector desk: water@greencape.co.za

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