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Improving our state of water resilience:
A private sector perspective

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Abstract
The private sector is heavily impacted by the major risk of water security, leading to grave financial consequences. Since 2017, the term 'Day Zero' has caused great concern to businesses, and raises questions by those dependent on these businesses. The dam levels in the Western Cape have since recovered significantly and that has led to relaxed water restrictions, but this does not entirely reassure the private sector of uninterrupted municipal water supply. Water is a precious commodity that needs to be wisely managed to serve the ever-growing population and promote economic growth.

While the Western Cape was rapidly approaching the daunting Day Zero, the consultant was approached by various private companies to provide professional services that would improve their resilience in response to water supply interruptions. This paper presents the experience, and lessons learnt, by the consultant and private sector, to assist the private sector to mitigate these anticipated risks. It elaborates on questions asked, initiatives identified, procedures followed, associated limitations and challenges experienced, and shares successes achieved.

The Draft Cape Town Water Strategy, published in January 2019, stated:

"The future is uncertain, and the cost of very severe restrictions is much higher than the cost of insuring against this likelihood by providing additional water supply capacity."

This emphasises the importance for private and public sectors to work together to achieve mutual success.

Introduction
South Africa is classified as a water scarce country where some projections estimate that South Africa at present, exploits roughly 98% of its available water supply resources. In many areas of South Africa the water challenge is looming ever larger. In certain respects the term 'load shedding' will potentially not only be synonymous with the provision of power, but with that of water as well, especially with the two commodities being mutually supportive in certain respects. When a severe multi-year drought, coupled with difficult water management parameters, is experienced, such as was the case in the Western Cape during the period from 2015-2018; water crisis conditions with serious implications and challenges are a reality for everyone concerned.

The ability of all stakeholders to respond wisely, lawfully and fairly in such a crisis becomes a daunting and complex minefield, especially to enterprises not knowledgeable of the requirements.

Facilitating water resilience
Given this background, we share our experience to encourage all municipalities as Water Service Authorities (WSA), as custodians of the law, and as Water Service Providers (WSP) (including sanitation services), to proactively increase their own resilience, and similarly encourage and incentivise their end-users to do the same to cohesively improve their response to water crisis conditions as a community.

Experience that initiated this paper
Various commercial, industrial, retail and government clients approached the consultant during the prevailing the water stress period brought about by the multi-year drought in the Western Cape, with the projected crisis of large-scale interrupted water supply, to alleviate their reliance on municipal water supply. Their objectives were primarily driven by commercial (loss of income) and liability concerns (in terms of safety and insurance requirements). However, idealistic aspirations of reduced long-term utility costs and reduced or independency of municipal water supply also played a role.

The influence of time constraints played a significant role. Some clients noticed the looming crisis, requested budget and engaged early. Some were more structured, but many left it too late and were required to respond to all these critical concerns simultaneously to manage the immediate and evident crisis.

The emergency solutions and mitigations encountered were, in some instances, quite innovative, while others were more radical, sometimes inadequate, high risk and beyond the legislative framework. Typical alternative water sources and water saving initiatives considered included, inter alia:

- *Water saving initiatives:* replacement of conventional sanitary fittings with water saving technology (in many instances there was misconception of what these technologies were, and the effectivity thereof), alteration of air-conditioning systems, conversion to dual plumbing water systems and addition of water suppression systems to supplement fire extinguishers.
- *Water sources:* rain- and greywater harvesting, reclaimed groundwater harvesting (collection of seepage groundwater or borehole water), blackwater and greywater treatment, potable water tanker supply (trucking water in via tanker water service) and use of bottled drinking water.
- *Other:* work from home to reduce business interruption; supplying employees with imported water instead of them having to queue for water during business hours and sparing them the inconvenience.

Challenges
When faced with the daunting task of implementing infrastructure to combat an unprecedented event, stakeholders can often over- or, worse, underestimate the level of intervention required. Needless to say, time was of the essence as Day Zero crept closer, with several aspects to consider, inter alia:

- Private sector companies are seldom knowledgeable or equipped to deal with water crisis interventions on a regular basis, possibly leading to an unwitting and/or hasty approach to implementing solutions.
- When interventions first started, legislation and guidelines for water resiliency measures for private application were progressively made available on different online forums. However, the general awareness, timeous and correct understanding and interpretation thereof posed a significant challenge to most clients. In certain instances, this had the potential to

(1) prevent the correct implementations from taking place from the start, and (2) costing time and resources from the business itself to determine the best course of action for implementing water resilient interventions under limited time, shifting risk parameters with potential long-term legal and cost implications.

- The objectives for business water resiliency interventions can differ considerably, from alleviating reliance on municipal supply to an attempt of going off the municipal grid completely, as well as abiding with auxiliary obligations (e.g. tenant agreements, public relations, etc.) to ensure water supply in times of interruption. The type of intervention can impact significantly on the timeline and cost of the interventions.

Legislation was amended and changed rapidly over the course of the water crisis, where the most notable laws affecting businesses in Cape Town are noted below.

Legislative framework in terms of alternative water supply

All three spheres of government have the legislative authority to draft and enact laws (legislation). All laws passed must not conflict with the Constitution of the Republic (1996), but must imbue the spirit thereof. Access to basic water supply and sanitation is a constitutional right that is afforded all people who reside in the Republic. This right is brought to action through the National Water Act (NWA), where the Department of Water and Sanitation (DWS), as the custodian of all the national water resources, is the functionary; and the Water Services Act, where local government acting as Water Services Authorities (WSA) are the functionaries.

Approval from DWS is required to use water as defined under section 21 of the Act. This approval or authorisation can be in the form of a General Authorisation or a Water Use License, if it falls outside the ambit of permissible use.

Once this proposed water use has been acknowledged and approved by the DWS, the next level of approval is with the WSA. The WSA is mandated, under the WSA, to progressively ensure efficient, affordable, economical and sustainable access to water services in the area of its jurisdiction. Therefore, in order to operate as a Water Services Provider (WSP) or a Water Services Intermediary (WSI), the WSA must cede, in part some of its duty to the applicant to ensure the provision of its mandate to the confined or restricted area.

The CCT has, as the WSA for the Cape Town Metropole, administrated and regulated the use and allocation of water through its Water by-law, updated in 2018, which is also, in water resiliency matters, supported through various other related by-laws, including:

- CCT Municipal Planning By-law (2015), specifically as it relates to building regulations which apply the erection of some structures and the connection of certain systems to water installations, of which the requirements for building plan approval are regularly amended.
- CCT Treated Effluent By-law (2010)
- CCT Stormwater Management By-law (2005)
- CCT Wastewater and Industrial Effluent By-law (2013)

It is prudent to bear in mind that all connections, installations and fittings that are conducted, whether from the council pipelines or internally inside the private premises of buildings within the City, must adhere to the published guidelines and SANS standards, including the National Building Regulations and Building Standards Act 103 of 1977 and its associated regulations and standards, in particular SANS 10400.

Further to the above referenced legislation there, is also a range of specific national standards (as upheld by SANS) that dictate the development, installation, operation and maintenance of the various elements associated with water intervention infrastructures. Depending on the location and environmental impact, other legislative acts and supportive regulations may also apply and require adherence.

Some of the technical, legislative and commercial challenges experienced are documented and summarised in the case studies below.

CASE STUDY 1

Background

Analysis and scoping of alternative water sources, which included the use of borehole water, storage and potential uses for non-potable water, was requested. The objective was to assess possible solutions to establish some assurance of continuation of business through a local water supply solution to augment municipal supply.

Most of the water used in the building was for air-conditioning, water closets and urinals. Only a small portion was used for other purposes. Drinking water was already being imported at the time of the investigation. The client is the tenant of the building, and thus affected the protocol in terms of responsibilities related to legislative requirements which differ from that of the building owner.

The project was rolled out in phases, starting with a scoping assessment to determine appropriate water supply solutions. This included the roll out of a status quo assessment of existing water systems, and use and optimisation thereof.

The timeline was driven by the Day Zero scenario which affected sequencing of investigations, implementations and authorisation procedures. Besides augmenting water supply, the objective was to implement solutions with the most significant improvement to optimise water usage, but would not require significant alterations that would culminate in major building alterations and disruption of daily business operations. Investigations and assessments were followed by detailed design and implementation.

Initiatives identified

The existing water system did not cater completely for an emergency situation, with 50% of the sanitary facilities tapping directly off the main supply. The existing dual plumbing system enabled easy manipulation for optimising overall water use and provided increased scope for using alternative water.

Potable water was used for flushing. Water closets and urinals were fed off a gravity flow system via storage tanks and all other potable water was fed directly off the municipal main, providing no storage back-up during interrupted water supply.

Since the potable and non-potable water systems were separated the risk could be defined, prioritised and managed (e.g. flushing of toilets could be prioritised as bottled drinking water could easily be imported from an external source. The importance of other potable use depends on the specific facility and its nature of business).

The introduction of additional storage capacity with a booster pump system not only improved general consistent water distribution throughout the building, but also provided temporary short-term water security with a back-up during interrupted water supply. As a result, pressure reductions on municipal supply would not affect daily building operation.

Storage tanks further provided easy integration with future incorporation of alternative water supply. Besides drilling a borehole, additional plumbing enabled easy access and capability for importing water from an external source as further emergency back-up.

The air-conditioning units used potable water. The focus to reduce the water consumption of the existing HVAC system was to either replace or augment the cooling tower system as this was where the water was

being consumed. Various scenarios, which use less or no water, could be applied. Any of the scenarios were expected to have an increased electricity demand of approximately 15%.

The determining factors were the cost versus slightly higher temperatures for 20% of the time. Spacing requirements and available areas for initiatives had to be considered, which included structural considerations, existing services and the like. Future clearance spacing and access during operation also had to be considered.

Restrictions and challenges

Various measures had to be put in place and considered in the design to prevent cross-contamination between potable and non-potable water, thus ensuring legislative compliance. Certificates of compliance had to be obtained for plumbing and electrical work associated with the changes made. Some confusion existed as to whether it was the landlord or tenant who needed to apply for the Water Use License. Ultimately, with the consent of the landlord, it was the tenant who had to apply and obtain approval. Due to the confusion of designation of responsibilities, the application process was delayed.

One of the requirements when sinking a borehole was to apply to the City of Cape Town. The client experienced that this process was tedious and the anticipated procedure rather vague.

Concluding remarks

The client decided not to treat groundwater for potable use, but rather treat it to non-potable standards, suitable for flushing purposes only, which was supported by the dual plumbing system. It also reduces the client's risk on compliance and capital and operational expenses.

The duration of a Water Use License Application (WULA) process, from submission to approval was expected to take roughly 300 days in total (160 days for the applicant and 140 days for the DWS to approve). The process could be expedited due to the nature and urgency of the activity.

CASE STUDY 2

Background and inception

The client was a large property group that owns multiple commercial and retail properties in various areas of the Cape Town Metropole.

The client initially leaned on their inhouse technical professional to assess the feasibility to access, treat and distribute alternative water sources, along with the respective impacts thereof. However, subsequent to increased pressure from tenants for the client to uphold their legal obligation to ensure safe workable conditions and mitigate the risk of exposure to the looming Day Zero, the consultant was approached to help assess and coordinate interventions.

Initially, nearly 30 properties that required intervention within an exceptionally short timeframe, were identified, but ultimately 19 properties were shortlisted.

Approach

The properties' existing infrastructure was assessed to inform the consultancy team to what extent intervention was required at each building. Current legislative requirements were taken into account, and one or more of the following water saving measures were identified and implemented at these properties:

- Storage tanks to provide at least two days' storage capacity, inclusive of reticulation to tie into existing plumbing infrastructure
- For building that consisted of dual plumbing, further investigation was conducted to introduce alternative water sources of variable quality as per the requirement of infrastructure and accommodation of plumbing systems
- Installation of infrastructure to secure alternative water available onsite, i.e. through sunk boreholes and groundwater harvesting
- Installation of infrastructure to treat and/or distribute water. Many of the properties lacked the requirements and capacity to collect and treat alternative water onsite and were thus reliant on properties that had surplus capacity in terms of access to alternative water sources.

Restrictions and challenges

While small-scale measures were implemented to curb the municipal dependency of the properties, such as importing drinking water, altering the HVAC systems and promoting a water saving attitude, more needed to be done to mitigate these properties' risk should Day Zero come, while maintaining the aesthetics of the buildings. Another consideration in terms of storage was to identify an appropriate location that would not cause loss in revenue due to, for example, parking bays being forfeited by tenants. This greatly restricted the open spaces that could be considered.

The installation of infrastructure also posed a challenge, given the short execution period and limited resources and approved vendors. This was mitigated to a great extent when Day Zero was moved to a later date, which bought all stakeholders and professionals more time to ensure effective implementation of water saving measures.

To secure alternative water sources onsite, one of the interventions was to sink boreholes in areas expected to deliver high yields. Theory and practice, however, contradicted one another in some instances where boreholes yielded far less than was estimated.

Due to the perceived cumbersome and long periods associated with obtaining a WULA (where the abstraction quantities would exceed the regulated limits set on volume abstraction, or trigger regulated sensitive activities), the client only actively pursued the use of alternative water sources at buildings with dual plumbing.

Access to, and the correct interpretation of the legislative requirements and potential exceptions during complete disruption of the municipal water supply, posed a significant challenge to the client and consultant when identifying and communicating on potential solutions and interventions.

Concluding remarks

An application for the client to register as Water Service Intermediary (WSI) was pursued to allow for the acquisition and supply of water to their tenants. The client was successful in procuring a temporary license and agreement with the City of Cape Town as the relevant Water Service Authority before Day Zero.

It is a lawful requirement for buildings over 30 m in height to be fitted with sprinkler systems as fire suppression systems. The sprinkler systems require their own segregated storage volume of water.

For buildings lower than 30m, the systems could be assessed for fire prevention, and augmentation of fire prevention and suppression systems that are not water dependent. Due to the cancellation of Day Zero, the requirements were never effected, but remained a worthwhile consideration.

Prior to the public cancellation of Day Zero, the client engaged in a high-level agreement with a trucking company who had access to other water service intermediaries who could treat water to potable

standards. The company confirmed that they could provide and distribute water according to the required demands and schedule.

Notwithstanding the challenges above, the client, consultant and contractors achieved the following:

- In a very limited period of time assessed the requirements for interventions and provided a prioritised strategy for intervention and mitigation of risks
- Managed to provide assurances to their tenants and insurance underwriters in terms of a water resilient strategy and intervention on their behalf.
- Identified various water resilient initiatives that could further be engaged by the client's sustainability team, post these initial interventions.
- Registered as a Water Service Intermediary and acquired rights to the abstraction, treatment and use of alternative water sources, at four properties.

CASE STUDY 3

Background

Interventions to alleviate reliance on municipal water supply at the premises of a municipal governing body was already in place. They requested that a study be conducted to assess the feasibility to integrate blackwater and/or potable treatment systems with the existing water infrastructure, and investigate the opportunity to completely step off the municipal water and sewer grid.

The building comprised a dual plumbing system and at the start of the study, the following water infrastructure and resiliency measures were in place:

- Potable municipal supply connection
- Groundwater harvesting plant at basement level. Water is treated here to non-potable standards and pumped to roof level for storage, where after water is gravity-fed to the water closets and urinals.
- Potable water and fire plant system at basement level, comprising enough storage for 1 day's supply to all sanitary fittings, excluding the water closets and urinals for which water is provided through the non-potable water system.
- Of the building's total consumption, ±60% is supplied through the groundwater harvesting and non-potable treatment system, while the remainder was through municipal supply.

Apart from the goal to improve independence of municipal supply, other key outcomes for the feasibility study were that any proposed implementation be in accordance with government and municipal legislation and be economically viable.

Initiatives identified

Through research and discussions with suppliers, a three-stage activated sludge system was proposed for the treatment of the building's domestic sewage blackwater. The plant sizing was based on its ability to accommodate high concentrations of wastewater, particularly taking the high ammonia content into account, since the building uses waterless urinals.

Further investigation was conducted to treat the groundwater on site, not only to the current non-potable standards, but to potable standards, as well and compare the cost implications of this to alternative potable sources in conjunction with lower quality potable domestic supply. Based on the water quality at the time, a reverse osmosis (RO) package treatment plant, followed by disinfection, was proposed to treat groundwater to potable standards.

Restrictions and challenges

One of the main constraints for this project was the location, which was confined to the second level basement. This would allow any major water augmentation infrastructure to be established in close proximity to the existing groundwater source and intercept existing water systems. Accessibility to said basement, due to height restrictions, proved cumbersome, limiting the type of treatment infrastructure considered.

Another point of contention was the groundwater quality, as mentioned previously. To remove the contaminants, multiple physical and chemical treatment processes need to be followed. The processes influence the operation complexity and, specifically for small plants, remain a challenge to manage well. As raw water quality at the same location can fluctuate, provision to accommodate these fluctuations can only be met to a certain point, limiting the plant's ability to treat highly variable water quality. The RO plant proposed allowed for a ±25% variance from set point.

The blackwater treatment plant cannot run solely on recirculated water and re-treated effluent. A portion of the building's wastewater effluent will still have to be discharged into the municipal sewerage system and some dilution of wastewater effluent will still have to take place (to meet discharge requirements defined by the associated by-laws) by means of adding municipal water or treated sump water, ultimately restricting the client's objective to become completely independent of municipal water supply.

The client advised that no intervention would be considered that would require a payback period exceeding 20 years, as such an expenditure would be difficult to justify.

Three combinations for intervention were identified, viz. (1) installation of blackwater treatment plant only, (2) installation of potable water treatment only, or (3) installation of both blackwater and potable water treatment plants. However, none of the options were within the specified payback period.

Concluding remarks

Though the options proposed were technically sound, the final decision rested on the economic feasibility which supported the existing water system to remain as is. It was advised that the flushing of toilets take precedence above all other water uses during a Day Zero scenario.

CASE STUDY 4

Background

A property investment holding company appointed the consultant to act as project manager on the installation of a potable water treatment plant at one of their Cape Town buildings. The plant would be supplied with water from two existing onsite groundwater drainage sumps. The water was to be treated to drinking water standards and fed into the main reticulation of the building. At the time of the consultant's involvement, a package plant contractor was already appointed, along with electrical, civil and plumbing contractors.

The scope of work entailed contract administration and site supervision, as well as the following:

- Specialist evaluation and recommendations on the potable water treatment plant specifications, proposal and quality
- Structural verification of slab loading capacity to carry the water treatment plant and associated infrastructure
- Specialist confirmation of fire safety requirements pertaining to building changes envisaged for this specific project

FIGURE 1: Visual examples of typical interventions implemented during the case studies, Figures 1 (a) to (d)

FIGURE 1 (a): Sinking of borehole

FIGURE 1 (b) Potable and non-potable infrastructure installed at roof level

- Pump and reticulation specifications to tie into the main building supply downstream of the treatment plant

Objective

Water flowed at roughly 140kℓ/day through the basement drainage sump, originating from a natural underground mountain spring. At the time, this water was wasted to the stormwater system, and created the perfect opportunity to rather divert this water to be used beneficially in an anticipated water scarce future.

The building's water consumption was roughly 45kℓ/day and the client obtained permission to become a water service intermediary only to supply water to those with whom it had a contractual obligation (i.e. tenants).

The client's objective was to implement these types of systems at properties with similar water sources and use the water to serve the needs of its tenants, effectively moving excess water off-site to other owned properties.

Restrictions and challenges

The use of basement water is regulated as a water use in terms of the Water Act, which created uncertainty in terms of compliance. Further, due to late stage involvement, it was difficult to identify the steps that could have been taken to streamline the process. In the stress situation, the client's primary focus was to obtain the necessary authorisation to distribute the surplus water as mentioned above, attending to obligations with greater affect. Treatment logistics were thus treated with lower priority.

A notable hurdle was reviewing the appointed contractor's package water treatment plant proposal for completeness after the fact (as they have already been appointed). The specification, set at request for proposal stage and on which basis the package water treatment plant was agreed to be designed, supplied and installed, lacked the aspects which could affect the following:

- durability of equipment
- health and safety
- compliance in terms of disposal to sewage and stormwater systems
- operation and maintenance.

Ideally speaking, addressing and providing specifications for these aspects at procurement stage could have reduced the overall risks, for both capital and operational costs. It could also have further streamlined adherence to compliance procedures. Through substantial efforts the consultant was able to improve on some of these identified challenges.

FIGURE 1 (c): Water treatment plant

FIGURE 1 (d) Sectional steel water storage tank

Concluding remarks

The initiative eventually enabled the client to take the property off the municipal water grid. At the time the client focused only on its Cape Town buildings in terms of stepping off the municipal water grid. They deemed that the City of Cape Town was the only City with legislation in place to enable this.

CONCLUSIONS

Through these case studies, several challenges that restricted the implementation of water saving measures were observed and identified, be it technically, economically or legislatively.

Water management is not the forte of most private sector businesses that take on water resilience interventions. They are thus in many instances unfamiliar with related legislation and restrictions. Emergency situations force people to react without being sufficiently informed, where a lack of guidance could further exacerbate the situation. Typically, many private entities do not realise the risks associated with sourcing, treating and using alternative water. They do not necessarily understand the legal restrictions, as well as the ongoing operation and maintenance, monitoring and compliance required. Beside the risks, there are capital and operational costs at stake. Facilitated procedures and assisted management of some of these activities can improve

FIGURE 2: A picture is worth a thousand words:

The reality of water stress conditions can sometimes be stark, and the facilitation and enablement of private sectors to fulfil their obligations of assuring continued water supply and increase water-resilient efforts in the communities they support are to be encouraged and supported. By facilitating the private sector, the general public is indirectly supported, further uplifting the wellbeing of society. (Photo by David Harrison/M&G, 2018)

water security and benefit stakeholders, notably the City of Cape Town's *Guideline for Installation of Alternative Water Systems*, published in February 2019, being a step in the right direction.

Not all interventions are equal either – various scenarios trigger different legislative requirements that need to be understood by the private sector, as their water system initiatives bear consequences that could impact the authorities' future strategies and operational procedures. Water resource yields and water quality is not a long-term guarantee.

Groundwater drainage sump yield is dependent on groundwater tables. This may also drop to levels with insufficient or no yield, especially during higher abstraction periods associated with water stress conditions.

During the water crisis, the private sector expected some level of support from the regional and provincial water service authorities. However, at the time of these case studies, formulated plans were in many instances not readily available, and measures were not implemented within a more ideal period of time to assist the private sector.

Although the water crisis was experienced in Cape Town, water stress situations can occur anywhere and at any time – making the lessons learnt from the Western Cape drought all the more valuable on a national level.

RECOMMENDATIONS

Based on the experiences during the Western Cape drought the recommendations allude to two major stakeholders, namely:

- Private property owners who wish to become more water resilient to water stress, and
- Water Service Authorities who are required to be proactive in facilitating water resilience initiatives to the end-users they serve and assist in managing a vulnerable resource

Private property owners can become more resilient against water stress conditions by:

- Reviewing their commercial and insurance obligations in terms of maintaining water supply
- Reducing their water dependency and consumption
- Familiarising themselves with the national and provincial legislation, regulations and restrictions in terms of water use and development of alternative water sources and systems
- Engaging with their local WSA on the local application and management of the national mandates according to local by-laws, restrictions and standards
- Considering local private-public partnerships in developing alternative water sources

Early stakeholder engagement can clarify many uncertainties and expedite procedures to establish a realistic and viable resilience plan.

Water Service Authorities need to consider the following activities:

- *Water sources:* Review the security, contribution and sensitivity of its water resources respective to drought conditions. This includes pollution control measures (acid mine drainage, wastewater, poorly treated effluent.)
- *Have a realistic water resiliency plan*, properly communicate the plan to the public and facilitate transition.
- *Infrastructure:* Review the ability and readiness of its bulk infrastructure to be able to operate intermittently at reduced flows and/or pressures. Consider contingency plans and interventions to reduce or control non-revenue water.
- *Legislation:* Ensure end-users have ease of access to all legislative, regulations which govern and facilitate their water use. Provide guidelines and ensure that authorities' technical and public leaders have a good understanding to enable them to direct and facilitate queries. Ensure that by-laws are flexible and adequate to facilitate the private sector; including well-defined in the case of emergency conditions accommodated for.
- *Governance and decision-making:* Ensure that the responsibilities, delegation of authority and decision-making forums in the national, provincial and managerial governance environment under which is operated in are clearly defined and understood in the event of water management to avoid conflict in attending to water management during water stress periods. The forums should not only be vertically aligned, but also horizontally aligned to adjacent and related governance and management structures, e.g. environmental, procurement, agriculture, and sanitation, among others.
- *Communicate and collaborate:* Reach out and educate the various end-users in different spheres such as industrial, commercial and retail, government entities and schools. Facilitate stakeholder forums and partner with the end-users in elevating their water resiliency measures. Use different media to inform the public and end-users, for example, an interactive and informative radio broadcast.
- *Commercial strategy:* When the water supply reduces, so does the revenue stream. However, the overheads and maintenance costs could potentially increase. Have a cash flow and commercial strategy for implementation during water restrictions and negotiate and communicate these in advance. Consider options for public-private partnership opportunities within stakeholder forums. Provide incentives to bulk water users to increase their resiliency and reduce their dependency on the WSA during water stress times.

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AECOM's unpublished work has been used for the development of this paper.

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