

PAPER 9

ACCESS TO CLEAN WATER: LESSONS FROM THE HAMMANSKRAAL EMERGENCY WATER TREATMENT PROJECT

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ABSTRACT

This paper identifies critical innovations in treatment technologies and delivery frameworks, offering a scalable model for infrastructure development across South Africa and globally. It also applies a qualitative case study methodology. It incorporates project documentation, technical performance reports, and publicly available governmental and media sources. Operational metrics were analysed in order to evaluate the efficacy of the system. Stakeholder interviews and published public statements were used to reconstruct the coordination efforts.

Beyond constructing a treatment plant, the project aimed to:

- rebuild public trust in service delivery,
- demonstrate the power of local innovation,
- offer a scalable and replicable solution to address national water infrastructure challenges, and
- circumvent threats from criminal interference and bureaucratic inertia.

The project served as a crucial test of South Africa's ability to rapidly and collaboratively deliver critical infrastructure, without compromising water quality or safety. The awarded tender specified the construction of four 12.5 megalitres per day (MLD) modular treatment units, housed within a single structure and equipped with an overhead crane to enable efficient installation and streamlined operations.

1 INTRODUCTION

1.1 The Background

Access to clean, safe drinking water is a persisting global challenge. Urbanisation, ageing infrastructure, water source contamination, and climate variability all intensify the pressure exerted on water supply systems. In South Africa, these problems are compounded by collapsing wastewater treatment facilities that pollute water sources, public health emergencies, inadequate rural services, criminal syndicates controlling water delivery, and political challenges.

South Africa faces a mounting water crisis that demands immediate and innovative solutions. Its water infrastructure is under unprecedented pressure due to a convergence of climate unpredictability, population growth, ageing assets, corruption, and institutional weakness (Hlahla & Hill, 2024).

Infrastructure News reports that many pipelines are over 70 years old. Pipe theft and meter tampering add pressure to already strained urban and rural systems, while vandalism and mismanagement further erode their reliability. Criminal syndicates, dubbed the 'water mafia', further complicate the implementation of recovery models for traditional infrastructure. In Gauteng, the *Financial Times* documents frequent water cuts, despite full dams, driven by ageing infrastructure, poor maintenance, and leakage approaching 35% of total supply. These failures have led to disease

outbreaks, including a cholera outbreak in Hammanskraal, which prompted the South African government to formally declare a national emergency in January 2024.

1.2 The Hammanskraal Crisis

Few have felt the effects of these challenges as keenly as the people of Hammanskraal and surrounding areas who have not had access to safe potable water for more than a decade, due to many of the barriers noted above including but not limited to:

- in excess of a 30% population increase over the past decade without any significant increase in potable water infrastructure or capacity
- aging infrastructure operating at well below design e.g. Temba Water Treatment Works, that historically provides the majority of water to Hammanskraal, producing 30 to 60MLD out of the potential 120MLD installed
- the compromised Rooiwal Waste Water Treatment Works, that has been in the spotlight of both local and international news, discharging raw or partially treated sewage into the Apies River resulting in heavily polluted source water for the already challenged Temba Water Treatment Plant which was unable to treat the source water to potable quality.
- criminal water cartels
- associated social unrest.

The crisis escalated in May 2023 when a fatal cholera outbreak struck the Hammanskraal community, drawing both national and international attention. As public anger grew, it became a symbol of state failure, institutional collapse, and political dysfunction. By the end of 2023, Hammanskraal had become emblematic of South Africa's water crisis.

National reports on the crisis, such as the Blue and Green Drop audits which confirmed that more than half of South Africa's water infrastructure to be in a critical state, identifies Hammanskraal as the area most urgently in need of intervention, due to the combined impact of source water pollution, infrastructure failure, and the cholera outbreak.

1.3 The Challenge With A "Traditional" Project Response

While traditional project response has been the backbone of the development of South Africa's infrastructure, it fall short in many ways in the face of Emergencies such as Hammanskraal. To address the crisis in a traditional way would have required, as a minimum, the compliance of Rooiwal and the refurbishment of Temba, a process that if approached through traditional mechanisms would have attracted timelines and costs that were many orders of magnitude beyond the pressing need.

It was clear that the crisis could only be addressed through new and forward-thinking intervention.

1.4 The Hammanskraal Emergency Water Treatment Project

Due to the strategic potential of the Klipdrift Water Treatment Plant under Magalies Water, the site was selected for the rapid delivery of potable water. The site benefits from ongoing compliance of quality and quantity



FIGURE 1: May 2024: Breaking ground

as well as, and most importantly, abstraction from the Pienaars River, a sufficiently clean water source suitable for the production of potable water.

In 2024, the Hammanskraal Emergency Water Treatment Project was launched in response to the crisis.

The project includes a number of packages such as increased abstraction capacity, a new 10ML reservoir, modifications and upgrading of the pipe network. At the heart of the project was the approval of a 50MLD emergency treatment solution, and Pro-Plan Consulting Engineers appointed Tecrover to deliver a modular package treatment system to address this requirement.

The project faced several systemic and site-specific challenges, in spite of which, the team navigated the project to successfully achieving the first 12.5MLD of potable water only 10 months after the tender was advertised:

- **Bedrock excavation:** unexpected geology required chemical breaking of rock, delaying module 1 (Tshwane Municipality, Polity.org.za (see Figure 1).
- **Energy instability:** a malfunctioning substation and Eskom's unreliable electricity supply caused delays (Polity.org.za).
- **Vandalism:** illegal taps compromised commissioning; enhanced security protocols had to be implemented (LinkedIn, Tshwane Bulletin, unpublished).
- **Upstream pollution:** Due to the ongoing malfunction of the Rooiwal Sewage Treatment Plant, the Apies River remained polluted, preventing full systemic recovery (Infrastructure News, unpublished data). To address this, the emergency plant was located at the Klipdrift Water Treatment Plant, (Infrastructure News) with the network reconfigured to draw water from Pienaars Rivier instead of the Apies River. This reversal of the water source bypassed the Temba Water Treatment Plant's reliance on the polluted Apies River.
- **Public distrust:** the community remained sceptical, despite official communications, necessitating transparent testing and outreach (News24, Parliament of South Africa).

2 WORLD-FIRST WATER TREATMENT INNOVATIONS AT HAMMANSKRAAL (THE CALABASH)

The awarded tender outlined the construction of four 12.5MLD modular water treatment units within a single building, equipped with an overhead cranes to enable fast deployment and streamlined operations (see Figures 2 and 3). Tecrover was appointed on the strength of a concept they proposed and immediately began developing, that challenged conventional technologies in order to meet the emergency needs of the project. The modular unit, designed by Tecrover and known as the Calabash, incorporates seven comprehensive treatment stages: dosing, flocculation, de-gritting, desilting, flotation, filtration, and disinfection.

While other modular plants have greater overall treatment capacities by combining multiple smaller modules (e.g., in facilities exceeding 100 million

gallons per day [MGD]), the Calabash is one of the largest modular package units globally. In addition, each Calabash includes the largest publicly documented single-unit moving bed media filter (MBF) to date (see Figure 4). The MBF being an alternative to gravity media filters which offers the many advantages listed below and in which the water is filtered upwards rather than downwards.

2.1 Treatment stages incorporated in the Calabash

The following subsections shed light on how the Calabash achieves flocculation, degritting, desilting, flotation, and filtration in a single modular unit without the need for individual structures for each step or the associated interconnecting pipes and pumps.



FIGURE 2: June 2025: 50 MLD up and running



FIGURE 3: July 2025: Three of the modular units visible from the overhead crane

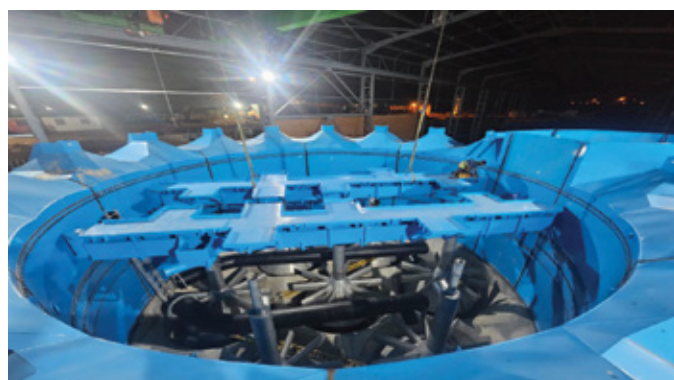


FIGURE 4: Inside the Calabash module

2.1.1 Flocculation

Flocculation, initiated by introducing a coagulant, - a chemical agent that neutralises the electrical charges keeping fine particles suspended in water-causes small particles that would otherwise remain suspended to form larger particles (flocs). The flocs can then settle out in a sedimentation tank or be trapped in a filtration system. The Calabash incorporates a circular tank that allows for the introduction of a coagulant before entering the flocculator, where gentle mixing facilitates floc formation.

2.1.2 Degritting

While the final solution includes sedimentation tanks to remove grit and sediment the Calabash was required to operate for 2 summer seasons without any upfront solids removal and a degritting feature was included as part of the flocculation compartment with all velocities prior to flocculation being maintained high enough to ensure no settlement in the feed network.

2.1.3 Flotation

Dissolved air flotation (DAF) is used in water treatment to effectively remove suspended solids, algae, oils, and other fine particles that are difficult to settle by gravity. Instead of allowing these impurities to sink, DAF systems lift them to the surface for removal, resulting in clearer, cleaner water for further treatment.

DAF operates by introducing microbubbles into the tank, which attach to the flocs. Due to the combined specific density of the flocs and microbubbles, they rise to the surface, forming a scum / float layer of algae and impurities. These are then removed through a process called descumming / defloating.

This process is especially useful for water sources that are heavily polluted or contain large volumes of light, buoyant contaminants. By incorporating DAF into the treatment train, the system significantly improves overall water clarity and reduces the burden on downstream filtration systems.

An innovative approach was developed to enhance microbubble generation in the white-water stream exiting the saturator. Rather than relying on multiple precision-engineered nozzles, this solution uses a purpose-designed internal restriction that produces a sharp drop in the water pressure, promoting fine air dispersion. The result is consistent microbubble formation and effective saturation, offering a significantly more cost-effective and low-maintenance alternative to traditional multi-nozzle systems.

The travel distance in the DAF was optimised to ensure float formation and settlement. Removal of float and silt in the DAF was researched and improved by experimenting with existing float formation systems.

2.1.4 Filtration

After coagulation, flocculation, and sedimentation, water still contains fine particles and micro-organisms. This water is directed into the moving bed media filter (MBF).

Filtration occurs through the media bed:

- The water flows upward through the media.

There are two particle removal mechanisms:

- Straining: large particles are physically trapped between media grains.
- Sedimentation: heavier particles settle between media pores.

Backwashing is achieved through the process of continuously, hence the term moving bed, lifting by means of an air lift pump, small quantity of media from the bottom of each filter cell through a sand washer, located above the media bed, where the sand is washed and returned to the top of the media bed.

To meet the design requirements of implementing this technology in a modular package plant, nine months of continuous research and development led to the implementation of a prototypal up-flow filter – the largest ever integrated into such a system.

2.2 The competitive edge of the Calabash

The Calabash units are able to achieve the following:

- 16.5MLD per unit (compared with the contracted 12.5MLD), setting global benchmarks (see Table 3).
- 50MLD achieved by three units (16.5MLD each), allowing the fourth to provide additional capacity or to remain on standby for use during maintenance at either the original or new plant.
- Energy usage under 50kW/ML of treated water.
- Hydraulic head loss of less than 2m.
- A horizontal plug-flow DAF with a 98–99% Nephelometric Turbidity Unit (NTU) removal efficiency during high NTU periods and almost zero short-circuiting.

The Calabash outperforms other systems in the following areas:

- Modular pre-engineered design for fast and cost effective implementation.
- Automated dissolved air float removal at between 3% and 6% solids, without any mechanical mechanisms and with minimal water loss.
- Separation of the DAF and filter, with silt collection at the bottom of the DAF, eliminating media blinding caused by settlement, a typical issue with the existing counter-current dissolved air flotation/filtration (COCO-DAFF) process.
- Separation of the DAF float and the waste stream (de-gritting, desilting, and backwash), combined with the high solids content of the DAF float, has reduced the required capacity of the float dewatering plant by two-thirds.
- Each unit has a single circular moving bed filter module with an active filtration area of 75m², containing 7 cells each with an active filtration area of 10.7m². This is, as far as the author is aware, the largest implementation of a moving bed filter module globally.
- Less than 5% total water loss through de-gritting, desilting, flotation, and backwash (see Table 2).

2.3 The advantages of using the Calabash

The innovative design of the modular package unit made it possible to deliver potable water under budget, just ten months after the tender was released to market. Its pre-engineered, modular design maximised off-site manufacturing and enabled the fast and cost-effective implementation of the project (see Figure 5).

The system has been designed to use fewer materials, less water, and less energy. By producing a smaller foot print than conventional water treatment plants and having a reduced environmental impact, it aims to protect natural resources. It is also more economically viable, having been implemented at a lower cost over a shorter period. Its modular design consists of robust, adaptable systems that are easier to maintain.



FIGURE 5: Running against timelines

TABLE 1: Plant Data

Performance During Highest NTU Events		
Date	2025/02/19	2025/05/13
Raw Water NTU	418	344
DAF Exit NTU	7,1	3,57
DAF Efficiency	98%	99%
Plant Inflow [m ³ /h]	475,2	468
Filtrate Water NTU	0,4	0,84

TABLE 2: Plant Data

Month	Raw Water Extraction [ML/day]	Average incoming NTU	DAF Exit Efficiency %	Filtrate NTU	Backwash Waste %
Jan-25	11,1	77,2	88%	0,63	7,4%
Feb-25	9,8	64	90%	0,49	6,4%
Mar-25	12,1	78	94%	0,46	4,7%
Apr-25	12,9	55,5	94%	0,45	3,7%
May-25	13,3	46,51	94%	0,45	3,0%
Jun-25	14,3	14,1	92%	0,51	3,0%

It boasts the largest circular moving bed filter modules globally. It is resilient by design, engineered to withstand environmental stressors. It can treat various water conditions, and has the ability to purify water with turbidity levels ranging from 1 to 400 NTU (a measure for how poor the water quality is). (See Table 1 and 2.)

The Calabash holds the following advantages:

- Utilises only 50% of the coagulant required by the existing plant.
- Enables automatic, continuous removal of float in the DAF, without moving mechanical components or labour-intensive methods.
- Results in an average water loss of just 3.5% during the continuous backwash process, with no system downtime.
- Reduces water loss during DAF float removal, improving the dewatering efficiency of the float.
- The continuous, gentle washing of the filter media doubles the lifespan of media in the sand filter.
- Each treatment unit has a single white-water nozzle external to the DAF, allowing maintenance and replacement without entering the DAF.
- Compared with a conventional plant, it is much less expensive to operate.
- Constructed in less than half the time of a conventional treatment plant.
- Consumes less energy than a conventional plant.
- Modular units are scalable and reconfigurable.
- Allows rapid deployment in emergency situations.
- Achieves 33% higher throughput compared to conventional plants.
- Requires less than half the space of conventional plants.

The efficiency and innovation of the project contributed significantly to value creation. Tables 1 to 3 provide data on the success of the system.

3 COLLABORATIVE ENVIRONMENT

The key differentiators that contributed to the project's success included the integration of a world-first South African water treatment innovation, an unwavering focus on service delivery, and a uniquely collaborative environment. This collaboration brought together all stakeholders: central and local government, the water authority, engineers, contractor, subcontractors, and local communities, and continued to grow as the project progressed.

Considering the adversarial and conflict-ridden environment that typically characterises the construction industry, the collaborative environment could be considered the project's greatest achievement. In addition, no delays were caused by construction mafia or community unrest.

What makes the project remarkable is the seamless alignment of national, provincial, and local authorities alongside private sector innovation. Key factors included:

- **Intergovernmental coordination:** Minister Majodina chaired regular oversight meetings that involved the Department of Water and Sanitation (DWS), Gauteng Province, the City of Tshwane, and Magalies Water.
- **Technical implementation:** Tecrover, through Pro-Plan, delivered the modular units, with Magalies Water as the implementing authority.
- **Security:** the Klipdrift Water Treatment Plant, which was declared a National Key Point, was protected by the South African Police Service (SAPS), Metro Police, and private security.
- **Community integration:** the City of Tshwane conducted network flushing, meter audits, and phased ward-level supply.
- **Public transparency:** the regular publication of water quality results and civic briefings helped rebuild public trust.
- **Government response:** by correctly identifying, acknowledging, and managing the non-potable water of Hammanskraal and its surrounding areas as a crisis that called for an emergency intervention, authorities enabled clear project intentions. This significantly reduced bureaucracy, provided ongoing support, interaction and progress monitoring, and enabled continuous feedback to all stakeholders.

This collaborative environment encouraged social responsibility and equity. With the full support of the local community, residents were employed and trained to assist in the construction, operation and maintenance of the unit. As a result, marginalised communities and all stakeholders were included.

4 PROJECT PRINCIPLES

The team prioritised principles that were followed in a strict order of precedence, with each principle regarded as ten times more important than the next, i.e. a logarithmic scale of Team 100, Service 10, and Repeatable Technology 1. This order of importance was necessary to prevent the reversal of priorities under pressure, often leading to conflict and impaired problem-solving.

4.1 Team: Emphasising collaboration and conversation at every level.

This principle was established on two foundational building blocks. First, the belief that because they are one people with one language, nothing they plan will be impossible for them (Genesis 11:6). Second, the understanding that

TABLE 3: Comparison to Similar Systems

Project/Plant	Cells per module	Cell Flow (m ³ /h)	Module Flow (m ³ /h)	Notes
Klipdrift (SA)	7	107	750	Likely the largest single-cell MBF documented
Parkson Hagerstown (USA)	10	30-50	300-500	Largest documented Parkson cell
WesTech Salmon WWTP (USA)	4	40-50	200	Standard WesTech SuperSand configuration
KHN (China)	8	50	400	Largest packaged skid

failure and conflict often result from a lack of dialogical communication. This principle established a project environment in which we managed to meet seemingly unobtainable objectives.

The above-mentioned project environment was consistently experienced at every level within the project. All involved were willing to do more than what was asked and recognised the value of the contribution of every team member. A key moment occurred during a site inspection and media briefing, when the Minister and the Mayor of Tshwane stated: 'It was those on the ground building the plants that should be celebrated for building the nation.' They then took their seat among the audience for photographs. An entire paper could be written on this point alone, and the spectacular impact that it had on the project's success.

4.2 Service: Maintaining focus on the project objective of delivering clean water.

A continuous focus on the project's intention to deliver potable water provided the shared vision that united the team towards achieving the common objective. It also ensured sensible decision-making that was in the best interest of the project, with the purpose/service promise remaining the guiding vision and priority of the project.

4.3 Repeatable technology: Designing with future replication in mind.

A mindset geared towards designs that enable future replication meant that the team achieved beyond the minimal contractual obligations. The solution not only met immediate requirements, it exceeded expectations.

4.4 Maximum benefit: Serving all stakeholders.

Rather than focusing solely on the minimum contractual obligations, the team prioritised a solution that would provide maximum benefit to all stakeholders involved.

4.5 Focus on innovation.

From its very inception, innovation has been the focus of the project both in setup and proposed solutions.

- There has been a clear understanding that because problems are dynamic in nature, innovative thinking is crucial. Old ways of approaching problems will not always suffice.
- This project's environment of innovation has paved the way for continuous development and improvement throughout the implementation of the project, and was a key driver of the project's achievements.

4.6 The adoption of a combination of project management approaches.

Adopting a combination of project management approaches made the real-time development needs of this project possible. This would not have been possible with the traditional waterfall, batten handing, or linear approaches.

Elements of Agile 2 – an approach that prioritises collaboration, open communication, and shared understanding – were combined with adaptive and package project management methodologies. This integrated approach enabled different aspects of the project to advance in parallel while ensuring they remained interconnected and aligned.

5 CONCLUSION

This paper identifies critical innovations in treatment technologies and delivery frameworks, offering a scalable model for infrastructure development across South Africa and globally to restore access to clean water swiftly and sustainably. It has become a benchmark of modular engineering and cross-sector collaboration.

Most importantly, the project reaffirmed that crises demand new thinking, because problems are dynamic in nature, innovative thinking is crucial. If future interventions are to succeed, our approaches must be adaptive, inclusive, locally grounded, and scalable. Key insights include:

- **Flexible project management:** blending adaptive, agile, and parallel approaches allowed technical and social elements to evolve together.
- **Community engagement:** transparency of water quality results and ongoing civic leadership helped rebuild public trust.
- **Modular, repeatable design:** solutions were created with replication in mind, ensuring that this was not a once-off success, but a potential national blueprint.
- **Team cohesion:** prioritising unity over rigid roles enabled multi-stakeholder coordination – from national ministers to field contractors.
- **Clear emergency designation and political alignment** were essential in accelerating timelines and cutting through red tape.

The Hammanskraal Emergency Water Treatment Project stands as a benchmark for managing complex infrastructure failures under critical conditions. It is not only an example of technological innovation, but also of systemic learning, collaboration, and project discipline.

6 RECOMMENDATIONS

The Hammanskraal Emergency Water Treatment Project should serve as a launchpad for future infrastructure solutions.

Its success lies not in isolated actions, but in a replicable method and mindset – one rooted in sustainability, speed, and cooperation.

Future initiatives should:

- Prioritise modular, scalable, and sustainable engineering designs across water and broader infrastructure projects.
- Create integrated delivery teams that bridge departments, spheres of government, and technical partners.
- Invest in technologies and systems designed for repeatability, agility, and localised adaptation.
- Ensure engineering decisions are directly linked to community impact, including long-term environmental and social outcomes.
- Foster a culture that rewards new thinking: problems are dynamic in nature; therefore, innovative thinking is crucial.

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