systems, will be accommodated, provided that the community in general, and the householder in particular, is amenable to the particular system, and provided the cost is comparable with a conventional VIP.

5. OPERATION AND MAINTENANCE

In considering the overall sustainability of any project, it is important to consider operating and maintenance costs. For VIP latrines, the masterplan notes that CHDM accepts that long-term maintenance of the sanitation facilities of a household qualifying for "Free Basic Services" remains a free basic service. Accordingly, when the pit of such an installation reaches the end of its service life, CHDM would either relocate the structure to a new pit and secure the old pit, or empty the pit, as appropriate. The cost of this would be recovered from the CHDM budget. This policy requires the size of the pit to be given careful consideration, and the implications will be illustrated later in this paper.

6. BUDGET, FUNDING, AND FUNDING STRATEGY

At the time of drafting (2009), the masterplan assumed the cost of a VIP to be R4 500 per unit, and calculated that the cost to eliminate the sanitation backlog in 102 757 households would be R462 406 500. The appropriate source of funding for this infrastructure is the Municipal Infrastructure Grant ("MIG"), but according to the Division of Revenue Act, the water services funding available to CHDM from MIG, even if applied to sanitation only, would leave a shortfall of R237 million. The IDP noted the need to identify alternate sources of funding, but, more importantly, noted that such alternate sources had not been found.

While CHDM fully supported the aim of the Strategic Framework to eliminate the sanitation backlog by 2010, and believed that it had the necessary technical and strategic capacity to achieve this goal, the significant funding shortfall would have to be addressed if this goal was to be attained.

The strategy that Chris Hani DM adopted to achieve the necessary funding was:

- This sanitation master plan would be submitted to the Department of Water Affairs for approval.
- When approved, and after any necessary adjustments, the master plan would be submitted to MIG for approval, and allocation of funds.
- If full funding was not approved, CHDM would proceed with full utilisation of the available funds, while pointing out to politicians that it would not be possible to achieve the target, through no fault of Chris Hani DM.

In practice, CHDM has not yet been able to guarantee the full funding required, and the tenders that were published, and the subsequent contracts, have made provision for variation (upwards or downwards) of the awarded value.

7. IMPLEMENTATION PLAN

The masterplan noted that the elimination of the sanitation backlog by 2010 could only be achieved through large-scale contracts by suitably-qualified service providers with sufficient capacity to undertake the necessary work. The scale of the necessary work and the short implementation time-frame are such that it would not be efficient practice for Chris Hani DM to employ sufficient staff to carry out the work in-house.

In order to ensure even distribution of sanitation delivery across the region, the backlog was distributed into eleven geographical clusters, and an appropriate number of suitable service-providers would be appointed, through the published CHDM Procurement Policy, to undertake the work.

Bidding for the work would be in two phases. In the first (technical pre-qualification) phase, bidders should demonstrate their expertise in, and familiarity with, all aspects of rural sanitation, with emphasis on the challenges to be faced. Specifications of requirements would be included in the bid document, but bidders would be free to expand on these and make their own proposals. While it was assumed from the extent of the backlog that the work would have to be carried out by large service providers or consortia, there would be limited need for bidders to prove their physical capacity to carry out the work in the first phase of the bidding.

In the second phase, only those service providers whose technical bids were found acceptable, and who had given an indication of sufficient capacity, would be invited to tender on execution of the work. The second phase would be a full, priced tender, incorporating all the elements necessary to ensure successful elimination of the sanitation backlog.

Departures from the usual sanitation contract custom would be:

- Institutional and social development ("ISD") issues would not have to be addressed by the VIP installation contractor, as this initiative is often misunderstood and poorly executed by conventional contractors. (Briefly, ISD includes alerting the communities to the sanitation-installation initiative, educating communities in health and hygiene related to sanitation, and negotiating community involvement and employment in the projects.) The ISD essentials would be carried out by specialist service-providers under the direct supervision of CHDM ISD staff. The ISD initiative would be launched in advance of any installation contracts.
- The Groundwater Protocol would not be applied by the installation contractor. This is another initiative poorly understood, and misapplied. The Groundwater Protocol is a protocol published by the Department of Water Affairs, in which the hydrogeological conditions in areas to be served with VIPs must be assessed to determine potential risk of pollution of ground- or surface-water. The groundwater Protocol would be applied area-wide by specialist hydrogeological service-providers who would determine areas of risk, advise CHDM, and instruct the installation contractors on any required amelioration measures. The hydrogeological investigation would be carried out in advance of any installation contracts.

An element required to be addressed early in the implementation of the project would be the final quantification of the actual backlog number.

Local Economic Development objectives would be served by requiring all materials (as far as possible) and transport to be sourced within CHDM, and preferably within local communities. "Factories" for manufacture of VIP superstructure components would be required to be established in the CHDM district, and these would preferably be multi-purpose, so that they would also provide components for other initiatives, such as housing. Ultimately, these factory sites might serve as service- and community-centres. All non-specialist labour for these factories would be sourced within the respective region, and formal training in the relevant factory skills would have to be provided to this labour.

Employment-generation would be enforced by the requirement that no mechanical digging be allowed, and that all VIP-installation labour be sourced from the respective local communities.

Early in the programme, the political level of CHDM was engaged to ensure full understanding of the project. In particular, ward councillors were briefed to understand that it would not be possible to provide employment to all their constituents, nor would it be possible to work in all the unserved areas simultaneously – some prioritisation would have to take place. The Water Affairs policy on sanitation stated that communities should be given options of various superstructures, but this would not be possible in this programme. The superstructure to be provided would be that offered by the successful bidder in each region.

8. IMPLEMENTATION PRACTICE

As with many well-intentioned grand plans, national elimination of the water services backlogs within the short time-frame was found to be impossible, and the deadline was relaxed to 2014. This had the benefit of allowing CHDM more time to achieve the required funding for the programme, which ultimately turned out to have a (tendered) value of R556 million.

CHDM gave further thought to the number of geographical clusters, and realised that administration of eleven contractors working in the different clusters would overstretch CHDM resources. The eleven clusters were reduced to four regions, and provision was made to appoint service-providers to augment the CHDM supervisory staff.

Ironically, a major constraint was found to be requirements set by the Construction Industry Development Board ("CIDB"), a regulatory body set up to benefit the construction industry. CIDB prescripts dictate the grading that a contractor must achieve before being permitted to undertake contracts of specified value – the higher the value, the higher the required grading. Given that the four CHDM contracts were likely to be higher than R100 million each (grading required = 8 or 9, the top two categories), and given that, at the time, most large contractors were likely to be committed to completion of the Soccer World Cup stadiums, it appeared unlikely that the CHDM tenders would attract realistic bids.

All the CIDB and Public Works Department (sponsors of CIDB) officials consulted were adamant that the required contractor grading was determined by the contract value. The argument that "the contract only requires the digging of one simple pit with the installation of a simple toilet structure over that pit, and this simply needs to be repeated 100 000 times" did not allow any relaxation of the value-related grading requirement.

However, the CIDB grading requirement does not (yet) apply to "suppliers", and a supplier is permitted to install their own product without infringing the CIDB rules. Accordingly, the tenders in preparation were modified to "supply, deliver to site, and install" tenders. This required more focus on the capability of the tenderers to supply the superstructures.

Tenders were called in two phases, as proposed by the masterplan. 42 tenders were recorded for the first phase, which was required to be a technical submission detailing the tenderers' experience in appropriate projects, methodology (including how adverse ground conditions would be addressed), how the proposed VIP would comply with the minimum specifications in the tender document, and the ability of the tenderer to meet the required supply and delivery rate (nominally 25 completed VIPs per day, per region). Tenderers were not required to be the suppliers; they could partner with appropriate suppliers, but the partnership had to be committed in the tender document, and it was made clear that the tenderer would be considered to be the supplier in the awarded contracts.

The 42 recorded tenders were evaluated against a 100-point scoresheet, of which 60 points were required to proceed to the next round. 8 tenders met the 60-point requirement, and a ninth tender was added later after registering an objection (This author personally feels that the challenge should have been defended.)

It had been intended that the first-phase tenders would seed a review of the specifications for the second phase, so that the best ideas could be incorporated in the final specifications. However, the CHDM Supply Chain Management division ruled that the specification could not be changed, and that the second phase must consist of a priced submission only (in addition to the claim for preference points). The first-phase document had specified that successful first-phase bidders would be required to construct demonstration VIPs, and this condition was allowed to stand in the second-phase bid.

Of the nine successful first-phase bidders, one opted not to participate in the second round. Eight tenders were received, but one invalidated his bid by declining to construct demonstration toilets.

Seven bidders were allocated sites at random in a rural settlement, and required to construct two VIP latrines. The first was to be a conventional VIP, and the second was to be a VIP-superstructure that would cater for wheelchair users. One of the superstructures was to be erected on a pit of 3 cubic metres volume, plus 500mm of clear freeboard above this volume, and the other built as if there was a solid rock outcrop at the surface. (Bidders were told to imagine that solid rock was at ground level on their allocated site, and that the intention was to evaluate how they proposed to build a pit latrine in such conditions.)

After construction, the pits and superstructures were inspected by a CHDM representative in the presence of each bidder. Dimensions and details were noted, and the inspection forms signed by CHDM and the bidder. Five of the bidders eliminated themselves from further consideration by digging pits that were smaller than the required 3 cubic metres. This might seem trivial, but CHDM had given careful thought to pit size on the grounds that the cost of moving or replacing VIPs in the future, once the pits were full, would be considerable, and therefore pit volume was a significant consideration. Tenderers who could not meet a specification on a single demonstration pit without the pressures of a full contract, would be unlikely to pay sufficient attention to pit size later.

Interestingly, one bidder, after having been told to imagine rock on his site, actually did have rock at ground level, which was then excavated with a "rockpecker". Apart from not meeting the required pit volume, this bid would have been rejected on the basis that a pit in solid rock constitutes a conservancy tank, which is not an acceptable solution. (In explanation: a pit latrine operates by allowing liquid to dissipate into the surrounding soil, whereas a conservancy tank retains everything placed in it, requiring periodic emptying by specialised means. CHDM does not have the means to empty rural conservancy tanks.)

The second-phase bid document noted that it was the intention to distribute the work among as many bidders as possible. Bidders would be awarded one, or possibly two, of the four regions, and only under exceptional circumstances would more than two regions be awarded to any one bidder. As it happens, the two remaining tenders after the evaluation of the demonstration units were so widely spaced in price that no justification could be found for awarding a region to the higher tender.

The four regions have been awarded to a single tenderer, an established precast concrete supplier, after negotiations to establish that the tenderer had the capacity to attend to the requirements.

One challenge was received (from the same tenderer who had challenged his original exclusion from the second phase). This challenge was successfully defended by pointing out that the bidder had inspected the demonstration units with the CHDM representative, and had acknowledged by his signature that the units did not meet the specification. Undertaking to rectify defects once the contract had been awarded could not be accommodated in the tender evaluation.

One unsuccessful tenderer queried the non-award of a contract to him, met with CHDM, and was satisfied that the consideration was solely based on tender value.

During evaluation of the first-phase tenders it was confirmed that CHDM would not have the staff to monitor the construction projects effectively. Concurrently with the second-phase tender, a tender for project management was published, with the requirement that tenderers should be registered project management professionals, or registered professional engineers. Four professional firms have been appointed to monitor the four regional contracts on behalf of CHDM, to coordinate the ISD initiatives in those regions, and to ensure that the contractor applies the recommendations arising from hydrogeological investigations. These firms have been required to take on, utilise and supervise local inexperienced graduates at reimbursable cost.

When it became apparent that it would be appropriate to appoint one tenderer for the VIP installations for all four regions, the tenderer proposed a savings if he would be allowed to construct and utilise only one pre-cast factory, in an urban centre. This proposal was given careful consideration, including at local political level, and found acceptable, provided that labour for the factory was drawn from each of the four regions, as originally required.

9. CONCLUSIONS

In previous sanitation tenders, tenderers have generally been consulting firms who have included full professional fees in their tenders, including mark-ups for the specialist work (if any) carried out by hydrogeologists and ISD practitioners. These tenders have been for a limited number of communities at a time, and thus unable to benefit from economies of scale.

By removing the specialist elements from the VIP contracts, the VIP contracts became relatively simple supply-and-install contracts, with the supplier able to concentrate on core business. Correspondingly, the specialists have been able to apply their skills on a regional, rather than micro, scale.

Conventional professional fees have been avoided, because there is no engineering design involved in the VIPs. The professionals that have been appointed to monitor the installations effectively augment CHDM technical staff, but will "walk away" at the end of the project, thus avoiding the need for CHDM to carry a large technical staff complement. Professional service providers were engaged to develop the required documentation for the hydrogeologists, VIP supply tenders, and the project managers (CHDM managed ISD procurement in-house), and the cost of this assistance was less than the gazetted percentage fee value for documentation alone on a contract of this size.

CIDB initiatives are fully supported by CHDM, and CHDM attempts to meet all CIDB recommendations and requirements. By defining the backlog-elimination project as a supply-and-install contract, CHDM has avoided what is considered to be an unrealistic contractor grading requirement. The grading requirement could have been reduced by breaking the contracts down to a low-value level (acceptable in municipal procurement regulations), but this would have resulted in impossible supervisory requirements.

In the context of South African municipalities struggling to come to terms with the services challenges, the CHDM approach to the sanitation backlog has shown enterprise and innovation. Contracts were only awarded in the second quarter of this year (2011), and while start-up has been a little slower than expected, there is no reason to suspect that the contracts will not run through to successful completion. Comments have been returned to the authors that lessons are being learnt that might have modified the approach to this project, but it is yet too early to define and document those lessons.

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BEAUFORT WEST WATER RECLAMATION PLANT: FIRST DIRECT (TOILET-TO-TAP) WATER RECLAMATION PLANT IN SOUTH AFRICA

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Abstract
Historically final effluent from a wastewater treatment works would either flow to the river or be used for irrigation. As a result of the topographical conditions in Beaufort West the Municipality decided to implement the first "direct" water reclamation plant in South Africa. The term "direct" is used because treated effluent from the wastewater treatment works is further treated and pumped directly back into the town's water supply system. The project was initiated and awarded to Water & Wastewater Engineering under a 20 year design, build and operate concession. The water reclamation plant has been completed and is fully operational, delivering water which is complying with the SANS 241-1: 2011 (Edition 1) standard. It is a ground breaking project in that it unlocks a significant water source that has historically either been over looked or under utilised.

Keywords: Beaufort West, direct water reclamation, advanced oxidation, constituents of emerging concern (CEC's), multiple barrier.

INTRODUCTION
Beaufort West is situated in the heart of the Great Karoo and is renowned for its vast landscapes, beautiful wild life and rich history. Beaufort West was the first town in South Africa to be proclaimed a Municipality, is the birth place of the world renowned heart surgeon Chris Barnard and now has the first direct water reclamation plant in South Africa. The Beaufort West Water Reclamation Plant (WRP) is only the second of its kind in the world. The other direct WRP is situated in Windhoek, Namibia. The term "direct" is used because treated effluent from the wastewater treatment works is further treated and pumped directly back into the town's water supply system.

WATER DEMAND HISTORY
What makes the Beaufort West water supply difficult is that it has no perennial rivers in the surrounding area. Water supply is heavily reliant on rainfall and drought is inevitable. The Municipality has two main sources of water i.e. surface runoff that is captured in the Gamka and Springfontein Dams and borehole water. During the recent drought both dams and approximately 50% of the boreholes dried up. Given this background the Municipality identified water supply as a key strategic resource and embarked on a short, medium and long term strategy to secure the water supply.

The short term strategy focussed on water demand management. This included detecting and managing water losses, installing pre-paid water meters, redeveloping existing boreholes, developing additional boreholes and implementing water restrictions. The medium term strategy focused on further groundwater exploration, water reclamation and desalination of existing saline boreholes. The long term strategy is to develop a field of boreholes 30 kilometres out of town.

After completion of the short term strategy and groundwater exploration, the Municipality embarked on implementing the water reclamation plant. Beaufort West Municipality asked tenders for the design, build and operation of the plant under a 20 year concession. After reviewing the various tenders received, the tender was awarded to Water & Wastewater Engineering.

Water & Wastewater Engineering used leading technology and applied innovative design in order to ensure optimal removal of organics and harmful pathogens. The design applies the "Multiple Barrier" principle to ensure the removal of:
• Macro elements;
• Physical and aesthetic determinands;
• Chemical determinands (macro and micro);
• Organic determinands;
• Contaminants of emerging concern (CEC)

IMPLEMENTATION OF THE PROJECT
The project was completed in three stages i.e. the EIA/planning stage, construction stage and the current operational stage. During the EIA process a lot of emphases were placed on informing all the communities of the proposed plant. From the outset it was clearly stated that treated effluent will be further treated and used for potable water. News paper articles were published and leaflets were handed out from door to door. During community meetings the proposed water reclamation plant was placed on the agenda and questions around the water quality was answered as transparent as possible. No major objections were received from the public and the EIA process was completed.

Construction of the plant commenced at the height of the drought. A decision was made to fast track the construction works. This implied civil and mechanical contractors being on site at the same time. Despite these challenges the project team managed to complete the project in six months and delivered the first reclaimed water on 15 January 2011.

Currently the project is in its operational stage and the plant is delivering reclaimed water of exceptional quality. Table 1 and Table 2 provide a summarised list of determinands being tested.

Determinand	Risk	Unit	SANS 241-1: 2011	Final Water	Compliance
Physical and aesthetic determinands					
Colour	Aesthetic	mg/L Pt	≤ 15	5	Passed
Conductivity	Aesthetic	mS/m	≤ 170	4	Passed
Total Dissolved Solids (Calculated)	Aesthetic	mg/L	≤ 1200	28	Passed
Total Dissolved Solids (Measured)	Aesthetic	mg/L	≤ 1200	34	Passed
pH value	Operational	pH units	≥5 to ≤ 9,7	6.5	Passed
Turbidity (Operational)	Operational	NTU	≤ 1	0.2	Passed

Table 1: Analysis of Physical and Chemical Determinands of the Reclaimed Water

Determinand	Risk	Unit	SANS 241-1: 2011	Final Water	Compliance
Chemical Requirements – macro determinand					
Ammonia as N	Aesthetic	mg/L	≤ 1.5	< 0.1	Passed
Chloride as Cl^-	Aesthetic	mg/L	≤ 300	8.0	Passed
Fluoride as F^-	Chronic Health	mg/L	≤ 1.5	< 0.1	Passed
Nitrate plus Nitrite as N	Acute Health	mg/L	≤ 11.9	1.4	Passed
Sodium as Na	Aesthetic	mg/L	≤ 200	7.4	Passed
Sulfate as SO_4	Aesthetic	mg/L	≤ 250	0.2	Passed
Zinc as ZN	Aesthetic	mg/L	≤ 5	< 0.01	Passed
Chemical Requirements – organic determinand					
Dissolved Organic Carbon	Chronic Health	mg/L	≤ 10	< 1	Passed

Table 1: Analysis of Physical and Chemical Determinands of the Reclaimed Water

Determinand	Risk	Unit	SANS 241-1: 2011	Final Water	Compliance
Microbiological Determinands					
Faecal Coliforms	Acute Health	Count per 100ml	Not Detected	0	Passed
E. Coli	Acute Health	Count per 100ml	Not Detected	0	Passed

Table 2: Analysis of Microbiological Determinands of the Reclaimed Water

MULTIPLE BARRIER TREATMENT
From the outset of the project a very conservative design philosophy was adopted. The project team knew that it was the first project of its kind in South Africa and that there could be no compromise on water quality. The design focussed on pre-treatment with multiple removal of determinants.

Pierre Marais from Water & Wastewater Engineering says: "From the outset the Municipality focused on proper pre-treatment. Mr Louw

Smit (Director of Engineering) was aware of the sensitivity of the project. The design had to incorporate safety measures with automatic shut down if there is deterioration in unit processes." Marais explains the treatment processes:

1. Phosphate Removal
Ferric-Chloride is dosed into the existing activated sludge plant to remove Ortho-Phosphates from the final effluent. The Ferric-Chloride also acts as flocculent for better settling of suspended solids in the secondary settling tank;

2. Settling
After the final effluent leaves the existing wastewater treatment works it flows to a settling tank. The settling tank settles the remaining suspended solids and acts as a buffer between the existing works and the new water reclamation plant;

3. Pre-disinfection
After settling of the suspended solids the feed water is disinfected with chlorine;

4. Filtration
The pre-disinfection is followed by gravity sand filtration. The sand filters remove all macro organic matter and any remaining suspended solids. This barrier also protects the down stream membranes from fouling as a result of shock organic loads or excess flocculent dosing;

5. Ultra Filtration
Ultra filtration is a membrane process where water is pumped through membrane straws. As a result of the nature of the feed water, outside-in flow direction membranes were selected. Ultra filtration membranes remove among other things Giardia, Cryptosporidium, bacteria and most viruses.

6. Reverse Osmosis
High pressure reverse osmosis membranes follow the ultra filtration membranes. The reverse osmosis membranes remove most remaining organics in the water, pesticides, hormones, CEC's, aqueous salts and metal ions.

7. Advanced Oxidation
An advanced oxidation step follows the reverse osmosis membranes. This process entails the dosing of peroxide followed by UV lights. The UV light catalyses chemical oxidation of organic contaminants in water by its combined effect upon the organic substances and reaction with hydrogen peroxide. First, many organic contaminants that absorb UV light may undergo a change in their chemical structure or may become more reactive with chemical oxidants. Second and more importantly, UV light catalyses the breakdown of hydrogen peroxide to produce hydroxyl radicals, which are powerful chemical oxidants. Hydroxyl radicals react with organic contaminants destroying them and producing harmless carbon dioxide, halides and water by-products. The process produces no hazardous by-products or air emissions. In short, this process is designed to destroy any remaining dissolved organic contaminants in the water.

8. Post Stabilization and Disinfection
Following the advanced oxidation the pH is elevated and a small amount of chlorine is added to protect the water until it reaches the end user.

9. Blending of Water
The reclaimed water is pumped up to a service reservoir and blended with the other water sources i.e. the treated dam water and borehole water. The mixing ratio is 1:4. The towns water is therefore made up of 20% reclaimed water. This ratio can be increased to 25%.

PERFORMANCE BASED CONTRACT
The asset (water reclamation plant) belongs to Beaufort West Municipality and Water & Wastewater Engineering operates and maintains the works under a 20 year concession. The contract is performance based and should the final water not meet the required standard, the plant is automatically shut down. A shut down results in lower volumes of reclaimed water produced, which in turn converts to a financial penalty. This ensures that Water & Wastewater Engineering continuously apply astute principles in the operation and maintenance of the plant.

CONTINUOUS EDUCATION
Despite the comprehensive planning and EIA process the initial public perception was negative. A comprehensive awareness campaign was launched with various groups and scholars visiting the plant. Today the people of Beaufort West are proud of their plant and very few objections are received from the community.

Continuous education campaigns, mainly for scholars, are underway. This is done by taking them through the plant and letting them taste, smell and touch 100% reclaimed water. This has been very successful and is planned to take place year to year.

In addition to the above the test results of the final water are made available to the public and these results are published in the local news paper.

FUTURE TESTING
Umgeni Water is currently in the process of determining selected steroid estrogens in treated sewage effluent in the Umsunduzi (Duzi) River water catchment area [1]. Part of the study is to determine the levels of Estradiol, Estriol, Estrone and 17-α-ethinyl-estradiol in a pilot plant membrane bioreactor followed by advance treatment. It is envisaged to embark on a series of similar tests at the Beaufort West WRP in order to compare the results of the Beaufort West WRP with that of the Umgeni Water study.

CONCLUSION
The Beaufort West water reclamation plant is fully operational and is delivering water that is complying with the SANS 241-1: 2011 (Edition 1) standard. It is a ground breaking project and unlocks a significant water source that has historically either been over looked or under utilised.

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