



CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD



WATER OUTLOOK 2018 REPORT

Revision 30 – Updated as at 31 December 2018

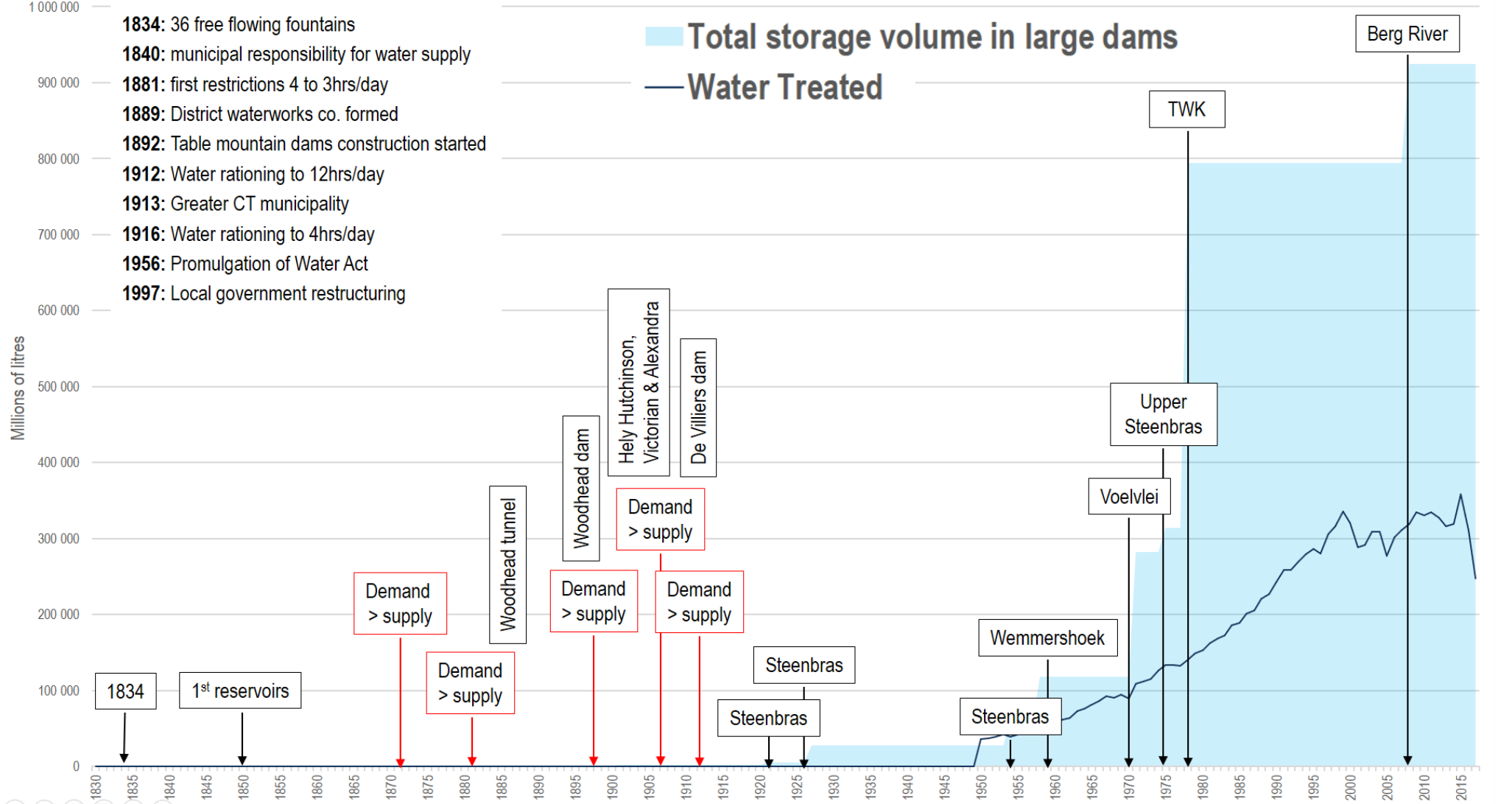
Produced by Department of Water and Sanitation

City of Cape Town

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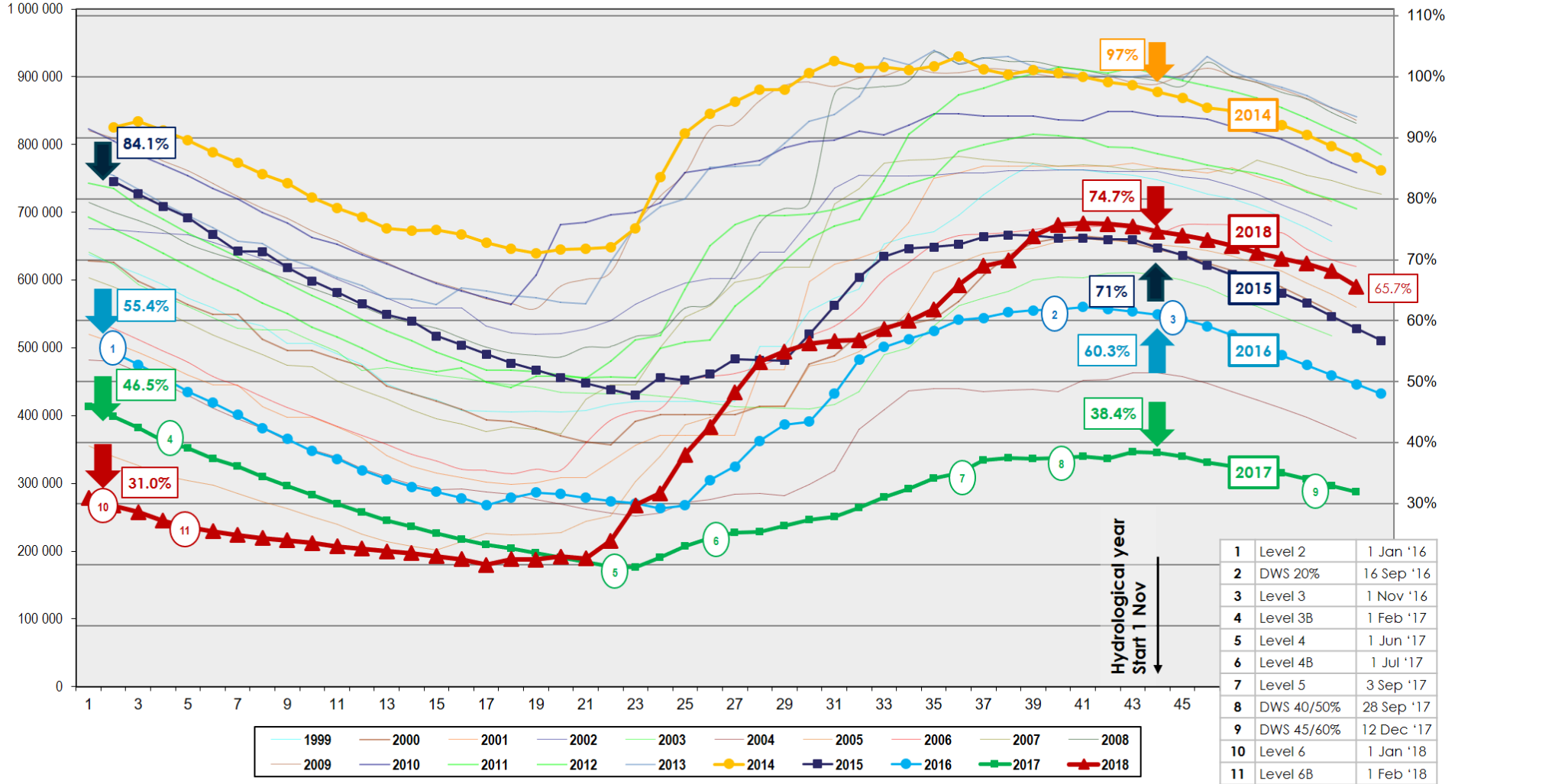
CAPE TOWN'S WATER: During 2017, information on Cape Town's management of the drought was limited. This caused much suspicion, distrust and significant misinformation. The Water Outlook was first released early in January 2018, developed to provide credible information to stakeholders which was easily digestible and covered the main themes emerging from public enquiries. During 2018, a number of updates were published (February, March, May, July, September) tracking progress of dam levels, demand, augmentation and finance. This is the final Water Outlook for 2018, and covers the status following the end of December 2018. [Previous versions are available here.](#)

Cape Town's recorded water history dates back to 1834, when the growing city was served by 36 free flowing fountains. Cape Town has been reliant on storing surface water (and water from springs) for nearly 170 years, since 1850. It being a winter rainfall region, storage had to be provided for dry summer months. Typically, in periods of drought, more storage capacity was added through the construction of reservoirs. The Greater Cape Town municipality also constructed several small dams on Table Mountain, which provided water for a growing population between the 1880s until the early 1900s. Only when raising the wall at Steenbras dam in the 1920s, was the volume stored sufficiently large enough to reflect on the current storage graph. Wemmershoek was the last new dam built by the municipality before the Water Act was promulgated in 1956 which assigned responsibility of bulk water resources to the National Department of Water and Sanitation (DWS). The three largest dams were built by DWS thereafter: Voëlvlei, Theewaterskloof and Berg River Dams. Most of the dams can be replenished during an average winter's rainfall while Theewaterskloof requires two average years to fill. Thus Theewaterskloof was designed to serve in drought periods. The line indicating water treated refers to treatment at Cape Town's water treatment plants and shows the long term demand trend (expanded upon later).



STATUS AT END OF 2018

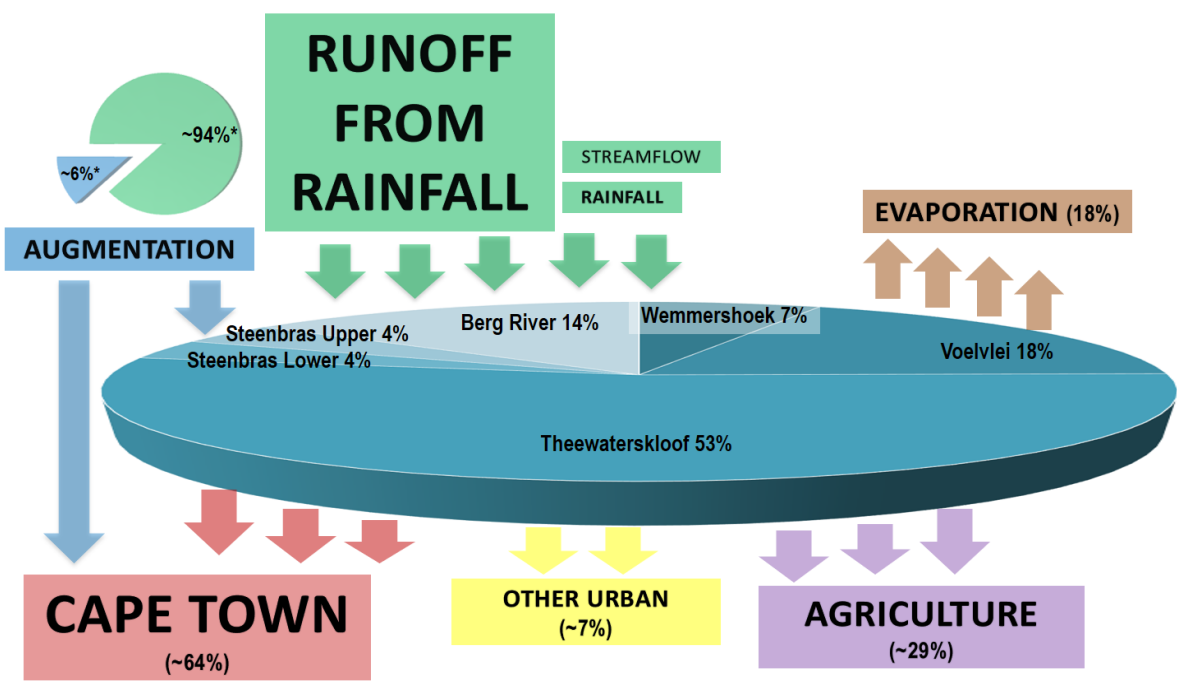
Dam behaviour: The graph below represents an annual view of the combined system storage volumes of the 6 major dams tracked over the past 20 years, highlighting the years from 2014 to 2018. Dates of the introduction of water restrictions by both the City and DWS during the drought are shown. In 2014 the dams last exceeded 100% of storage and spilt over, resulting in available storage capacity of 84% at the beginning of 2015, the first dry year. Poor rainfall led to 2016 starting with storage capacity at 55%, followed by a further below-average rainfall year in 2016, which left dams at only 46% of capacity in January 2017. The extremely low rainfall in 2017 is evidenced by the flat slope of the green curve in the second half of the year, resulting in a starting volume of only 31% in January 2018. Through aggressive demand management (both urban and agricultural) and close to average seasonal rainfall in 2018, dam levels ended the hydrological year at 74.7%, an increase of nearly 55% from the lowest level of ~20% reached at end April 2018. At 31 December, dams were at 65.7% of full capacity.



Who provides water to Cape Town? One of the initial misconceptions in the recent drought was that the City of Cape Town (the City) is solely responsible for the provision of water to Cape Town, in part due to taking early leadership in communications around the drought. Importantly, Cape Town is part of the Western Cape Water Supply System (WCWSS), which gets its water from a system of 6 major rainfed dams that supply the region. WCWSS covers the West Coast district municipality and local municipalities of Drakenstein, Stellenbosch and Witzenberg. The City provides bulk water directly to parts of Stellenbosch and Drakenstein municipalities.

In the WCWSS, Cape Town utilises ~64% of water, agriculture ~29% and other urban areas 7%. DWS manages the 3 largest dams in the system, which contribute 85% of the system storage while the City of Cape Town manage the balance (Steenbras Upper & Lower and Wemmershoek). The system is connected through a complex system of pipelines, canals & tunnels managed by DWS in collaboration with the City to maximise yield.

Of the City dams, Steenbras Upper is kept as full as possible as it provides for distribution over a wide area. From its elevated location, it can feed either Faure water treatment plant via the lower electricity pumped storage dam at Firlands, or Steenbras water treatment plant via the Lower Dam. Some water is held for the efficient operation of the Steenbras hydroelectric power station. The City also has a number of small dams in its control such as those on top of Table Mountain, with storage capacity of ~4.4 million cubic metres (MCM). DWS is responsible for determining allocations, implementing restrictions, planning and for effecting water resource schemes to meet water demand for cities, industries, mining and agriculture. During 2018, Cape Town provided approximately 6% of the system demand from own sources, including augmentation projects while evaporation accounted for ~18% of system demand.

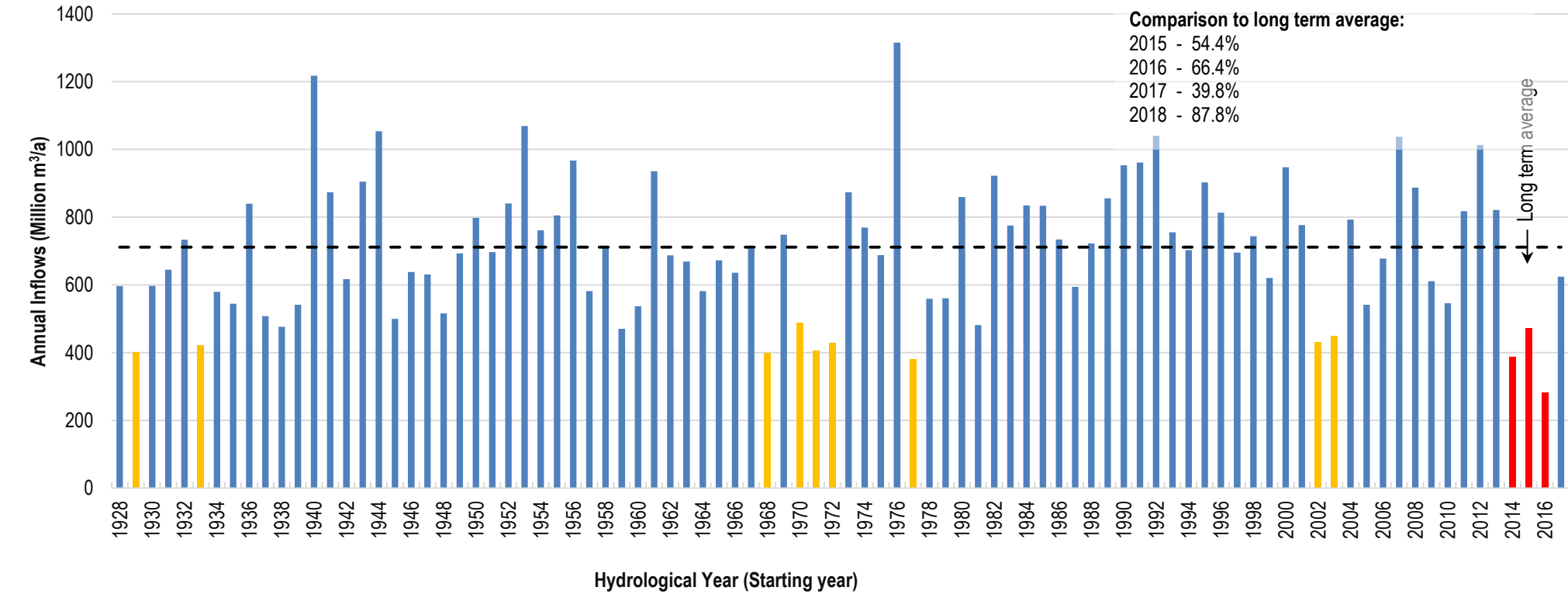


*Based on 2018 augmentation vs TOTAL demand

Dam	Capacity (Mega litres)	% of total	Dam level at 1 Nov 2017	Dam level at 31 Oct 2018
Theewaterskloof	480 188	53%	27.2%	57.9%
Voëlvlei	164 095	18%	28.5%	96.1%
Berg River	130 010	14%	68.6%	99.3%
Wemmershoek	58 644	7%	48.3%	91.8%
Steenbras Upper	31 767	4%	100.0%	72.3%
Steenbras Lower	33 517	4%	53.7%	86.6%
TOTAL	898 221	100%	38.4%	74.7%

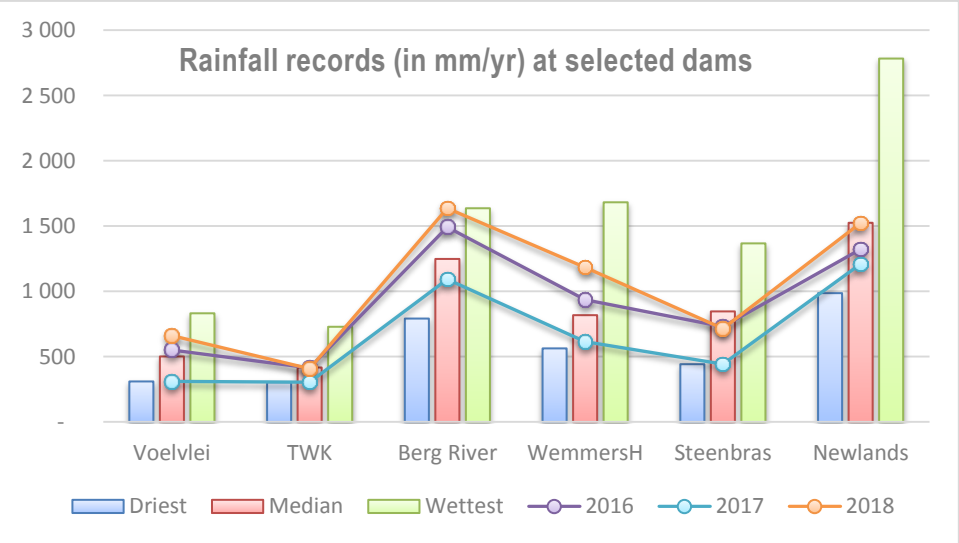
Water available during the drought: The City's allocation from the system is largely at a 1 in 50 year level of assurance of supply which means that during droughts with a severity of 1:50 years or more, restrictions need to be imposed to reduce demand. Agriculture typically pays less for water at a lower level of assurance. The restrictions imposed by DWS in 2017 were based on a 45% saving by urban users and 60% by agricultural users on the average unrestricted use over the previous 5 years. The system's hydrological year runs from 1 November to 31 October. Cape Town's target total consumption for the 2017 hydrological year was 174.7 MCM based on 45% saving – a 41% saving was achieved. Agriculture had a targeted restriction total saving of 60% and achieved approximately 57%. Releases were stopped when allocations were reached. A preliminary

retrospective analysis showed that if the system had been operated optimally and in accordance with the documented allocations and rules, dam levels could have been in the region of 55% at the end of winter 2017. This is a theoretical, calculated number and is unlikely to have been achieved in practice. Nevertheless, the analysis does point to the importance of all role-players being actively involved in the management of the overall system as this would have significantly lessened the severity of the crisis.



Rainfall and Runoff: The preliminary runoff calculations indicate that 2018 rainfall resulted in flows below the long term average, but more than twice that of 2017. Annual inflow is shown in millions of m³/annum, with the long term average at 711 MCM. The three years from 2012 – 2014 had above average runoff while the past 4 years have been below average. Climate scientists agree that it is too early to tell whether the drought has broken – it is too early to say that there has been a step change to lower rainfall but also too early to say that there has not.

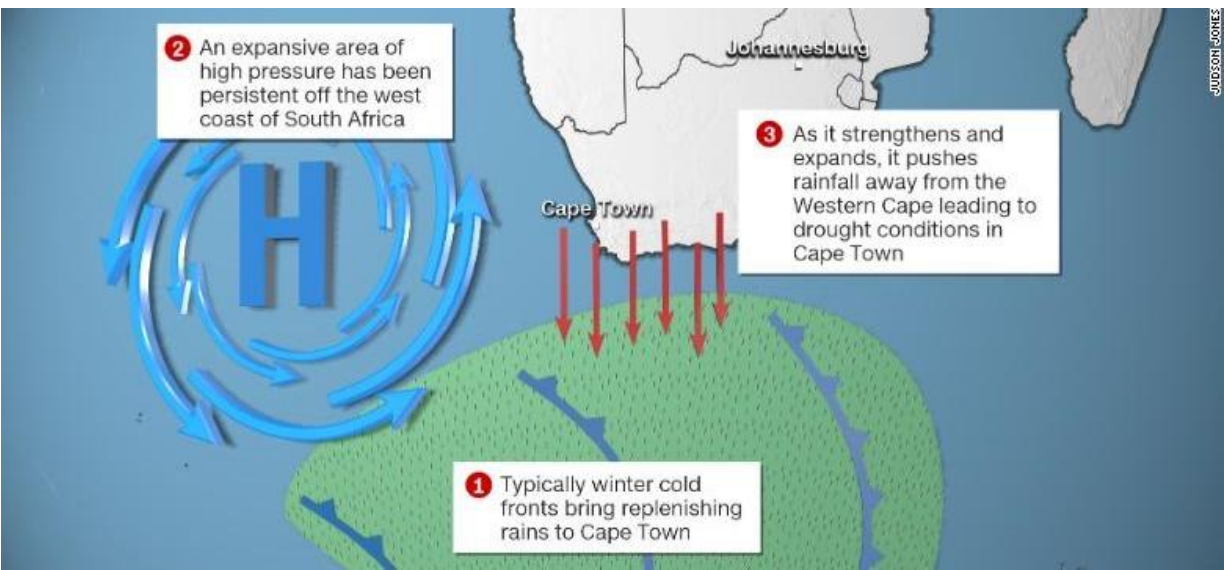
The annual rainfall in mm/year at the major dams as well as at Newlands is shown in the bars below for the driest, wettest and median records. The last 3 years' rainfall totals are tracked. The large variation in rainfall over the recorded history is notable. As can be seen, the variability also applies across the catchment area serving the WCWSS – the rainfall station at Berg River dam recorded the highest rainfall in history the 2018 winter, while Steenbras had below average rainfall in all three years. While rainfall measured at a single station cannot be directly correlated across the dam catchment, it is indicative of variability. The statistics are also influenced by the length of the rainfall record.



Weather outlook: ENSO (El Niño-Southern Oscillation) has had a marked impact on SA weather in the recent past. Typically, winter cold fronts driven by strong westerly winds bring replenishing rains to Cape Town. But the past few years have been anything but typical. "An expansive area of high pressure situated in the Atlantic Ocean is acting as a barrier to these weather systems," CNN meteorologist Derek Van Dam says.

"As this high-pressure system strengthens and expands, it pushes rainfall away from the Western Cape." This area of high pressure has been unusually strong over the past three years and the result has been three years of drought, including their two driest years on record in 2015 and 2017. This increase in drought frequency and severity is an expected consequence of a warming planet".

According to the Intergovernmental Panel on Climate Change's fifth assessment report, long-term climate models indicate a significant drying trend will continue across western portions of South Africa, possibly reducing annual rainfall by up to 40%ⁱ. The South African Weather Service climate watch report from Dec 2018 to April 2019 does not indicate any specific markers for temperature or rainfall in the supply area. At this point it is too early to say with confidence whether (or not) there has been a step-change in rainfall, or in fact whether the drought has broken. Confidence will improve over the coming years, and the City will proceed with caution on the status of the drought well into winter 2019.



Drought recovery: As the dam levels increased, the pressure on DWS and the City to provide relief increased. The principle risk areas were:

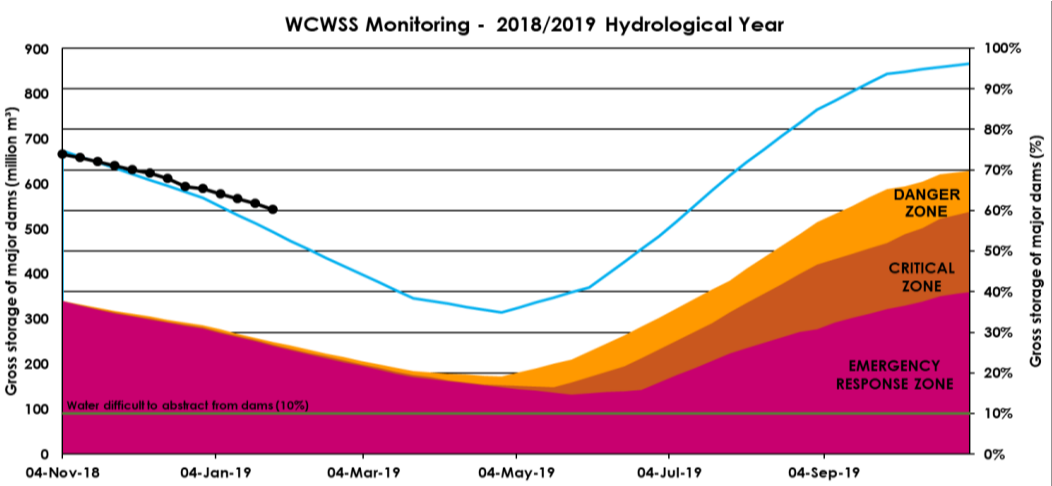
- While rainfall in 2018 was close to the long-term average, it is still too early to tell whether or not there has been a step change in rainfall or whether the drought is over;
- Having imposed severe restriction tariffs, consumer behavior cannot be accurately predicted, and the City tried to move through restriction levels one by one rather than implementing major changes which would impact on the financial sustainability of the water & sanitation business.

Restrictions were imposed by the City on 8 occasions during the drought, with the requirements shown here: Prior to 2017, the City had 3 restriction levels, with tariffs for each level approved by Council annually. The unprecedented drought prompted the introduction of levels such as 3B, 4B and 6B, where additional conditions were necessary to further reduce demand which were not readily aligned with approved tariffs. A Level 4 tariff was first introduced in 2017/18 which further penalized domestic use at high volumes. A domestic charge was introduced for the first 6kl per household from July 2017, at approximately a quarter of cost. Prior to this all households received the first 6kl per month at no cost. Given the extreme low rainfall in winter, it became apparent in spring 2017 that household consumption had to be reduced to 6kl or less. The City thus applied to the Minister of Finance for special approval to introduce additional tariffs for water & sanitation during the year, and moved to Level 6B tariffs from 1 February 2018. The City developed a flexible drought recovery plan, which could adapt to the rate of dam level increase and gradual reduction of restrictions without adding unnecessary risk to storage volumes, at the same time ensuring financial sustainability balancing revenue with volume of sales.

Date	City/DWS	Tariff	Demand (MLD)	Target demand	Combined dam level	Limit pp	Requirements
1 Jan 2016	City Level 2	2	1000	700	55.4%	-	• Watering restricted to specific days and hours • No specific daily limit • No automatic pool top-up
16 Sep 2016	DWS 20%	-	-	-	61.5%	-	• 20% curtailment of all water use
1 Nov 2016	City Level 3	3	900	650	60.3%	-	• Watering restricted to using a bucket for potable water • No pool top up without pool cover
1 Feb 2017	City Level 3B	3	800	650	38.7%	-	• Watering restricted to using a bucket for potable water during certain hours only
1 Jun 2017	City Level 4	3	660	600	19.4%	100	• No watering allowed with potable water • Daily limit of 100 lcd encouraged
1 Jul 2017	City Level 4B	4	625	600	25%	87	• Daily limit of 87 lcd encouraged
3 Sep 2017	City Level 5	4	600	500	36.1%	87	• Daily limit of 87 lcd encouraged • Households limited to 20kl/month • Non-residential restricted to 20% saving compared to previous year • Agricultural users to restrict to 30% saving compared to previous year
28 Sep 2017	DWS 40/50%	-	-	-	37.6%	-	• 40% curtailment of all domestic and industrial water use • 50% curtailment of all agricultural water use • The WC Provincial Head is delegated power to lift the water restrictions should the WCWSS recover to above 85% before 1 November 2018
12 Dec 2017	DWS 45/60%	-	-	-	34%	-	• 45% curtailment of all domestic and industrial water use • 60% curtailment of all agricultural water use
1 Jan 2018	City Level 6	4	600	450	31%	87	• Daily limit of 87 lcd encouraged • Households limited to 10.5kl/month • Non-residential restricted to 45% saving compared to previous year • Agricultural users to restrict to 60% saving compared to previous year
1 Feb 2018	City Level 6B	6	560	450	25.9%	50	• Daily limit of 50 lcd encouraged • Households limited to 10.5kl/month, but 6kl/month encouraged • Non-residential restricted to 45% saving compared to previous year • Agricultural users to restrict to 60% saving compared to previous year
1 Oct 2018	CCT Amended Level 5	5	520	500	75.9%	70	• Daily limit of 70 lcd encouraged • Households limited to 10.5kl/month • Non-residential restricted to 40% saving and agricultural users to 50% compared to corresponding period in 2015 (pre-drought)
1 Dec 2018	CCT Amended Level 3	3	~550	650	70.3%	105	• Daily limit of 105 lcd encouraged • No household limit and percentage reduction restrictions not applicable for non-residential and agricultural users

Current Restriction level: Due to continued dependence on rainfall and uncertainty around variability of rainfall and impact of climate change a precautionary approach must be followed to safeguard the supply system from having to move to such extreme restriction levels again, and movement to lower levels of restriction carefully considered. Based on the latest model run, DWS imposed restrictions of 10% on both urban and agricultural users based on lawful water allocations, gazetted on 3 December 2018. Cape Town voluntarily agreed to a 30% restriction on allocation, which is a conservative position given that it is too early to declare the drought to be over despite good dam recovery.

WCWSS Yield	Cape Town	Agriculture	Other Urban	Total
Unconstrained Allocation Mm ³	324	144	23	570
2018 Restricted allocation (Mm ³)	178	58	13	248
2018 Average restricted daily demand (MLD)	488	158	35	681
2019 Restricted allocation (Mm ³)	243	152	16	411
2019 Average restricted daily demand (MLD)	666	416	44	1,126



Cape Town moved to Level 3 restrictions from 1 December 2018, providing tariff relief to customers, along with an increase in theoretical individual use to 105 lcd. The daily target demand for the City under current Level 3 restrictions is 650 MLD. Dam behavior based on 10% agricultural and 30% urban savings with average rainfall is shown as the blue line in the WCWSS monitoring graph. Should demand, evaporation and rainfall occur as conservatively modelled, dam levels (as shown in the graph) will bottom out at slightly above 35% in May 2019.

The reduced level of urban demand agreed to in the current season safeguards dams for future years. Modeling indicates that reduced rainfall (for example should rainfall be similar to 2017 for the next two years) will result in safe dam levels without more extreme *urban* restrictions required while agriculture, after the current year's relaxation to 10%, would require *far harsher restrictions should such poor rainfall eventuate*. The system restriction imposed by DWS for 2018 and 2019 is shown adjacent. During the height of the drought, the City was restricted to an average annual daily demand of 488MLD. With a 30% restriction this has increased to 666MLD without jeopardising dam levels.

CAPE TOWN'S 2018 DROUGHT STRATEGY

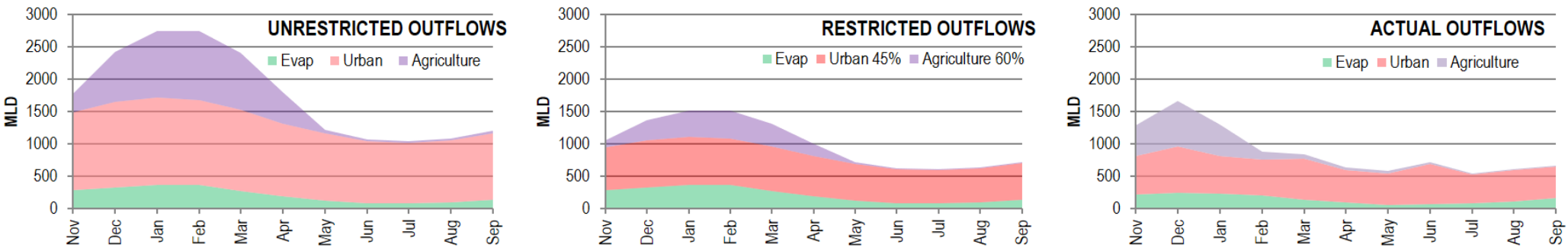
As this is the final Water Outlook for 2018, it covers the conclusion of Cape Town's drought strategy. Getting through to the rainy season required a three-pronged approach **A:** managing the remaining water in the dams, **B:** managing demand down as much as possible and **C:** bringing on-stream water from other sources (ground, re-used and desalinated).

A: MANAGING DAM LEVELS

Dam behaviour was modelled conservatively on 2017 runoff data in 2018. Dam levels typically decrease from releases to Agriculture, the City, other municipalities, and through evaporation. The City together with DWS monitors dam levels, and publishes change in dam levels and consumption every week. Tracking urban and agriculture demand against allocations was also included on the City's water dashboardⁱⁱ late in 2017. Comprehensive information is included in the City's extended weekly water report. This includes comparison of current dam levels to that of the prior 4 years, tracking urban and agricultural consumption against restrictions, water quality compliance and weekly rainfall records.

Based on how dam levels are tracking against the anticipated behaviour, decisions around further restrictions are made by DWS on the WCWSS and by the City on City restriction levels. It was evident that for every day that the usage target from the system was exceeded, it became more critical to use less as the over-use had to be recovered by future reduced demand.

Out-flows from the system are shown graphically. Daily demand varies seasonally, specifically for agriculture and evaporation. Urban demand fluctuates very little compared to historic patterns, with demand typically increasing slightly on hot days. Modeling assumed maximum calculated evaporation. Unrestricted, the system demand typically peaks in summer at over 2,500 MLD based on allocations made from the WCWSS. Under the severe drought restrictions the calculated peak was at approximately 1,500MLD, using the maximum evaporation. The actual outflows shown on the right indicate early draw-down of agriculture, while urban matched the calculated outflows fairly accurately. It is evident that agriculture was curtailed virtually completely by the end of February, having reached the allocated volumes. Actual evaporation in 2017/18 was lower than the maximum calculated.



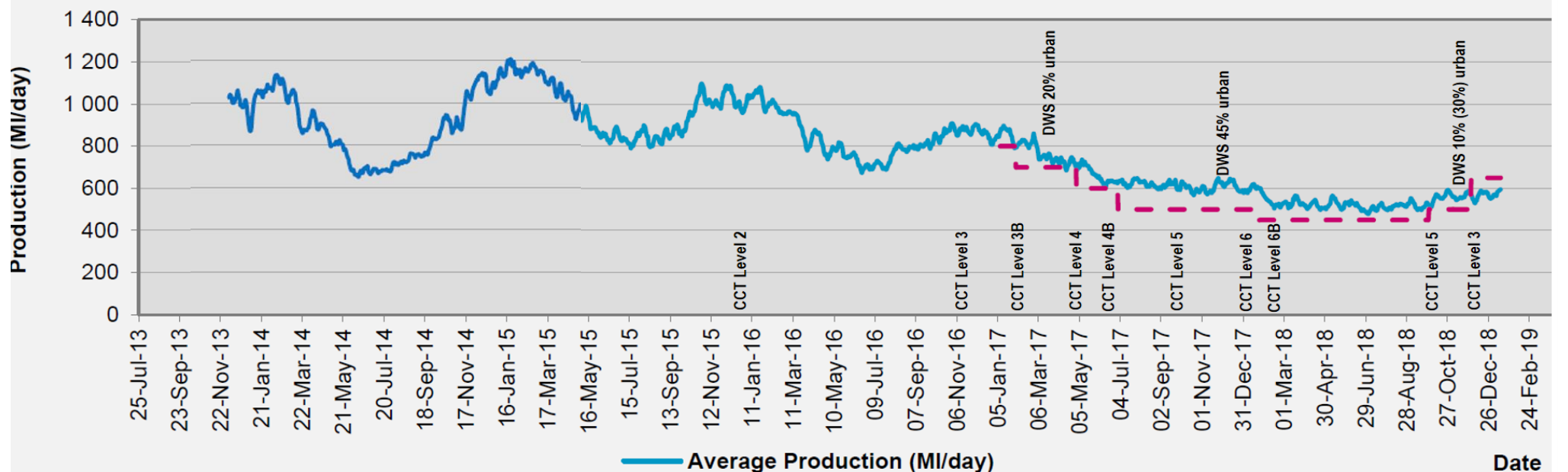
Public interest is considered in the design of the dashboard and it will continue to evolve as required, to serve needs for monitoring and decision making to best effect. The City Water Strategy includes a commitment to management of water as a resource across the WCWSS: “**Shared benefits from regional water resources:** The City will work with key stakeholders and partners, including other urban and agriculture water users, and other spheres of government, to make the most of the opportunities to optimise the economic, social and ecological benefits of regional water resources, and to reduce the risks. The City will do this through collaborative processes”. The City also commits to facilitate transformation of Cape Town over time into a **Water Sensitive City** that makes optimal use of stormwater and urban waterways for the purposes of flood control, aquifer recharge, water reuse and recreation, and is based on sound ecological principles. The first step in achieving this was to incorporate the Stormwater planning branch into the Water department.

B: MANAGING DEMAND

The second component of the City strategy to overcome the drought was managing the City's demand. 70% of Cape Town's water demand by volume is from the domestic sector, with the balance being industrial, commercial and institutional (ICI). Of the domestic volume, approximately 5% is used by informal settlements, which comprise roughly 15% of all households. While all users had to decrease demand, the main focus of demand management was on formal domestic households. To manage daily demand requires that each person should use no more than the defined volume per day, whether they are home, at work or elsewhere. Reaching the overall demand target is only possible if individual use is curtailed. The peak summer consumption in Cape Town in 2015 was ~1200MLD. In summer 2015/16 under level 2 restrictions this reduced to a peak of ~1100MLD. By summer of 2016/17, a peak of ~900MLD was achieved under Level 3 restrictions. Between June and December 2017 demand stabilised at ~600MLD. Since January 2018, the City managed to reduce demand to closer to 500MLD. In terms of the restriction required by DWS, this had to be further reduced to 450MLD to meet the restricted allocation.

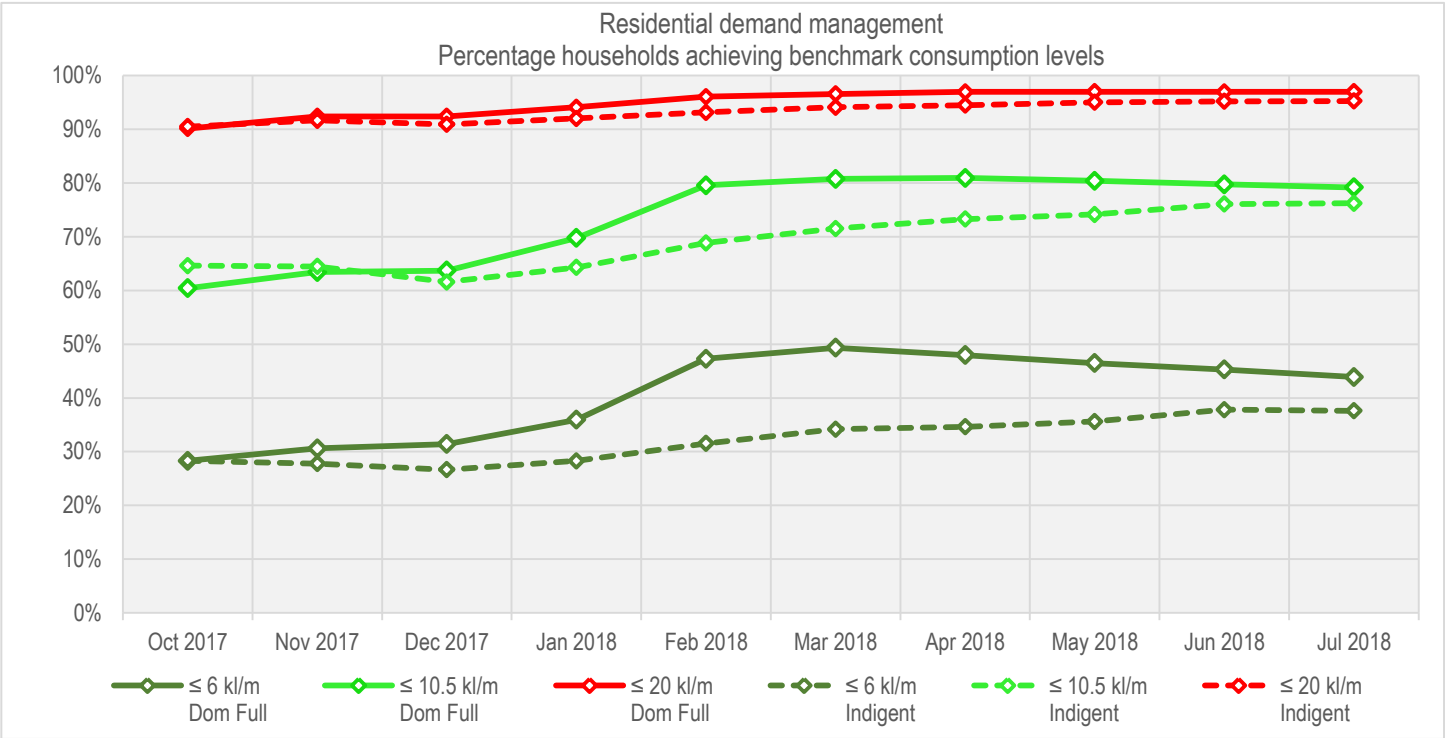
What the City did:

- Progressively increased restrictions to Level 6B:** Level 6 was enforced from 1 January 2018, and 6B from 1 February 2018. The target had been reduced to 450MLD. Daily individual consumption had to be limited to a maximum of 50 lcd to be aligned with Level 6 tariffs. 4 million people at 50 litres per day = 200MLD. Approximately 150MLD is consumed by industry, commerce, government etc. This results in 100MLD less than the daily target of 450MLD. The inability to adhere to restrictions thus far meant that a stretch target of 50 litres was appropriate to ensure that the 450MLD target was reached



- Communication campaigns:** Every person in the city had to realise that this is a crisis. The City launched numerous communication campaigns to assist people in reducing their consumption, such as household leak detection & repair and how to use 50 litres, and continued to use radio, print, social media and direct engagements to reach every citizen and mobilise to reduce consumption to 450MLD, aligned with 6B restrictions. The communication campaign was adapted as restriction levels changed. Communications played a very important role in demand management and lessons learnt in translating technical information for general understanding and public use will assist in future communications campaigns on municipal services.

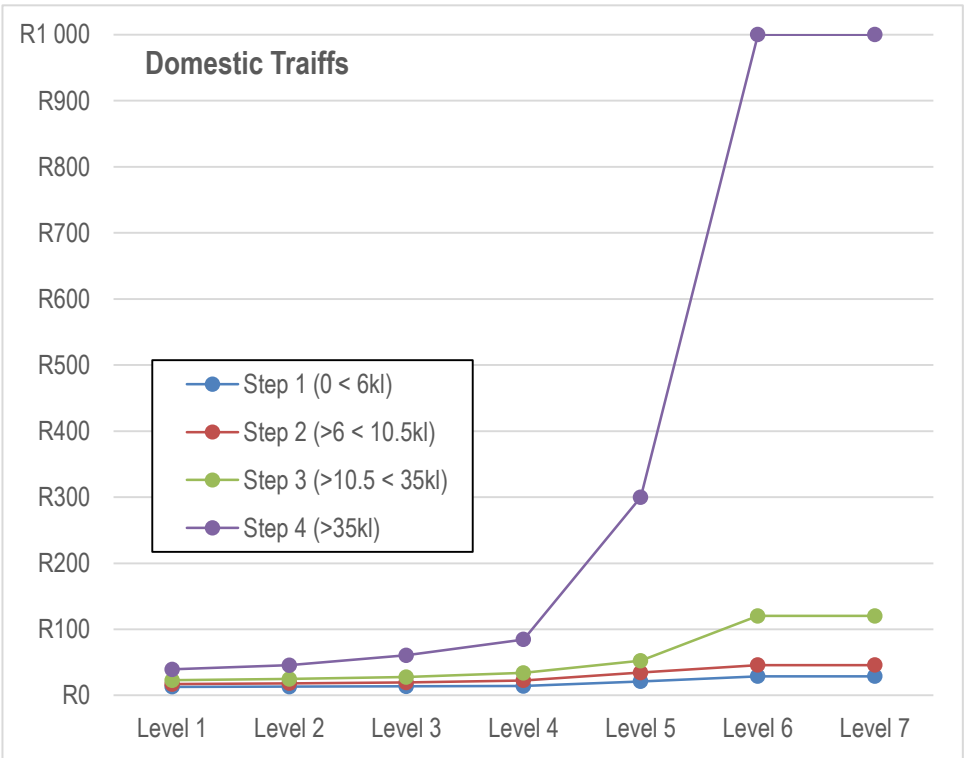
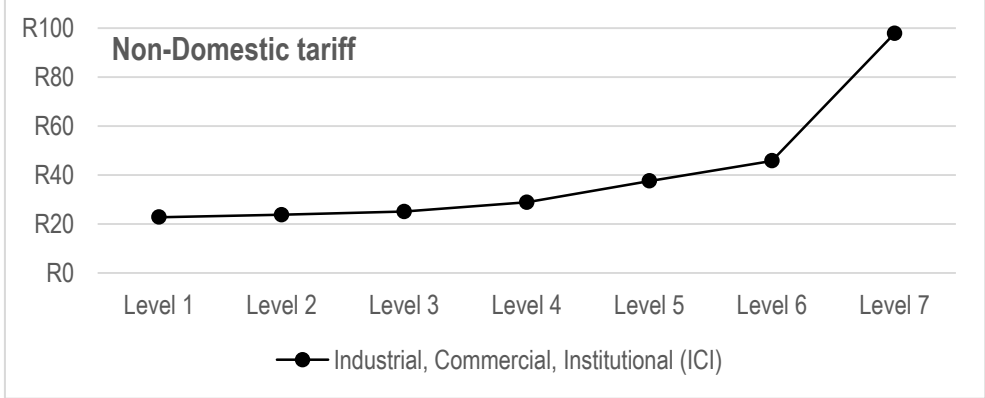
• **Water Map**ⁱⁱⁱ: Promoting public awareness by transparently providing ample information to empower citizens has been a cornerstone of the City's drought response and a key aspect of its conservation strategy. The water map was one of the more innovative and perhaps controversial behavioural tools used by the City to encourage water savings. The main goal of the water map was to publicly acknowledge households that saved water, thereby normalizing water conservation by creating an online spatial viewer using geographic information system data of the City to display markers. Dark green dots indicated actual consumption below 6kl while light green was used below 10.5kl. Where consumption was estimated, a grey dot was used. The City never moved to showing red dots, which would indicate use above 20kl per month, but this could be deduced by the absence of a dot. Over time, it is evident that the number of households using less than 10.5kl stabilised at around 80%, and less than 6kl, around 40%.



• **Pressure reduction**: Municipal water distribution systems often supply water at pressures significantly higher than the minimum required for good service. International research over the last two decades has shown that these excessive pressures have several negative effects on distribution systems, including higher pipe failure rates, larger leakage rates and reduced capital service life. Pressure reduction was initiated in Cape Town more than a decade ago. The programme was aggressively accelerated in December 2017 to automate newly identified zones across the City to optimise the system and reduce demand - especially the impact of leaks. Pressure zones were used to force down consumption by throttling zones to the extent of partial supply if user behaviour in the zone was high in an effort to meet the daily water budget. Average savings peaked at 70MLD from pressure reduction, leak detection and repair, and indigent household leak fixing.

• **Household flow regulators**: The City has been installing water management devices to manage debt for many years. In October 2017, the programme was dramatically ramped up to households who had not reduced consumption sufficiently to restrict daily household consumption and safeguard against the impact of leaks. A household of 4, each person using 50 lcd results in a monthly consumption of 6,000 litres per household. The allowance is per day, whether at home, work or school. Note also that the average household size in Cape Town is 3.2 people. In many cases high use was due to undetected leaks, but under level 6 restrictions, the City had been installing these where consumption was higher than 10.5kl/month. The rollout was aimed at addressing highest consumption first, with a target of 3,000 installations a week. The average number of installations between October 2017 to July 2018 was ~1,500 a week, and reduced in line with the number of households with excessive consumption. In the first 6 months of 2018, the number of high consuming non-indigent households reduced by 61% and high-consuming indigent households by 44%. The rapid rollout resulted in spikes in WMD "no-water" notifications of which the majority of calls logged were due to undetected leaks and households depleting the daily allocation and not due to faulty installation or meter issues (~15%). While Level 6 restrictions were in place, consumers were urged to be vigilant in leak detection as the current tariffs result in bills rapidly ramping up with excessive water use.

• **Punitive tariffs**: Restrictions go hand-in-hand with stepped tariffs, charging more for water use at higher volumes. Progressively more punitive tariffs were introduced on inclining blocks so that higher use of volumes came at an increased cost. A Level 6 tariff was introduced on 1 February 2018 where punitive tariff applied to all use over 50lcd. As households were required to dramatically reduce consumption, the volumes in higher usage steps shrunk considerably. Step 1 & 2 (up to 10.5kl per month) was still provided as free service to indigent households at Level 6. Non-domestic (ICI) tariffs are charged at a flat rate per kl without a stepped tariff. The City engaged with large and small business with possible solutions to reduce consumption and limit the impact of large tariff increase. ICI tariffs doubled between Level 3 and 6. The dramatic increase under Level 7 was necessary for the emergency Day 0 response. Domestic tariffs at Level 7 remained static given that domestic use would largely be cut.



What happened with Agriculture? Agricultural restriction was set at 60%. DWS is responsible for regulating and controlling use, including releasing water for agriculture. The City has been working with DWS and the Western Cape Provincial Government to ensure that releases are controlled – as at the end of February 2018, DWS stopped releases to those irrigation boards who had reached their allocation increasing confidence that the agricultural restriction target would be met;

And other urban areas? Similar to managing agriculture, DWS is responsible for managing other urban use. The outflow to other urban is relatively small. Cumulatively other urban centres met restrictions and were monitored to prevent exceeding targeted consumption.

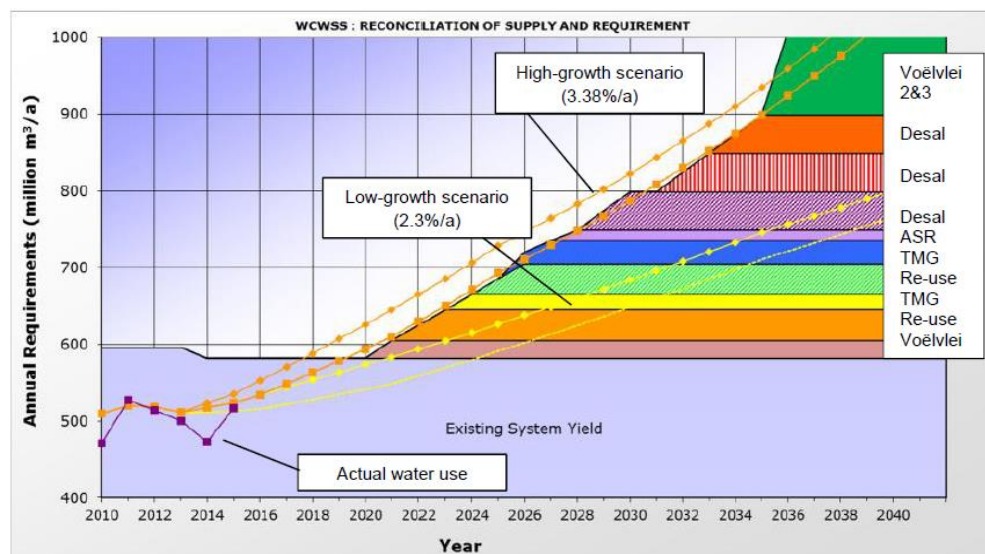
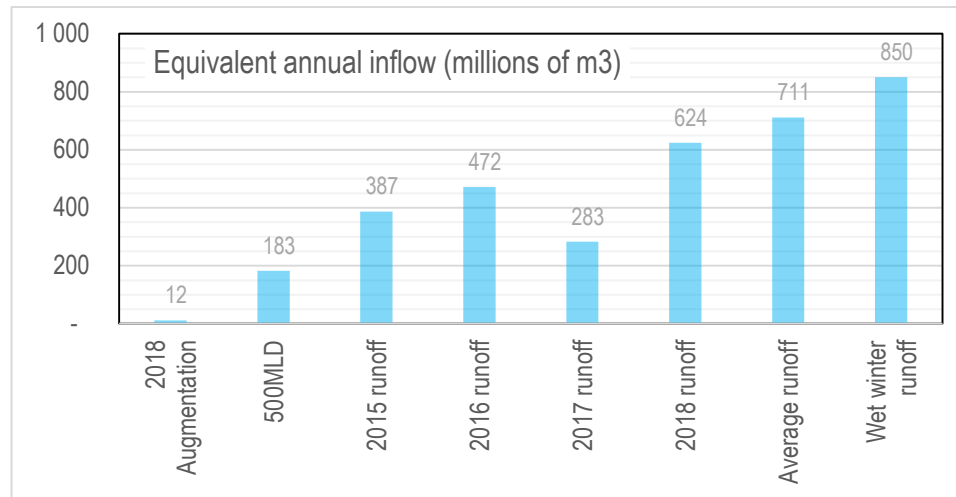
To reiterate, to make it through the drought and into the rainy season, we needed to ensure management of releases out of the dams, reduction in demand that drives these releases, while maximising water flow into the system.

C: AUGMENTATION

Non-surface water augmentation schemes are a much more expensive source of water compared to rain-fed dams. Even under very poor rainfall conditions such as that experienced in 2017, the volume of water added to the dams was 283MCM, the equivalent of ~720MLD. In contrast, providing augmented water of 500MLD would result in equivalent inflow of 183MCM. For practical reasons Cape Town will continue to rely significantly on surface water from rainfed dams. Augmentation efforts in 2018 resulted in a total inflow of just over 12 Mm³, while equivalent inflow from rainfall added ~624MCM to the WCWSS dams.

Reliability of the system will be increased by adding diversified water sources including ground water, re-use and desalination. The costs of these schemes must be compared to the cost of water from dams which is ~R5.20/kl to ensure financial sustainability.

The augmentation programme has evolved significantly since the introduction of the Water Resilience programme in May 2017. Third party expert advice on augmentation resulted in a change in focus at the end of 2017. This was again confirmed in 2018 when a second desalination expert provided advice to the City. The cost of water sources other than surface water necessitates careful consideration given the permanent impact of augmentation on the water tariff. There thus needs to be a balance of implementation of augmentation projects without incurring excessive fast-tracking costs.



In the long-term, it is possible to provide water security through significant volumes of non-surface water. The sustainable yield (with recharge) of the final phase of licenced ground water sources exceeds 200 MLD. In addition, Cape Town could produce over 200 MLD of potable water from wastewater. The quantity of water available from the sea is only constrained by the high cost that would be incurred in desalination. Of the three 'new sources' of water – ground water, wastewater reuse and seawater desalination – only desalination is totally independent of rainfall.

DWS is responsible for developing further surface water schemes which form part of the WCWSS Reconciliation Strategy. The Reconciliation Strategy was developed to ensure reconciliation of future water requirements with the supply from the WCWSS. The Strategy regularly reviews future water requirement scenarios and reconciliation interventions to meet the water requirement, for the next 25 years.

The reconciliation strategy is currently being updated by DWS, incorporating the updated hydrology, reduction in yield due to spread of invasive aliens,

augmentation triggered in the past two years and the impact of the three-year drought. The 2016 reconciliation is shown here.

Responsibility for non-surface water schemes has not been conclusively defined. Where groundwater enters the municipal reticulation system, it appears logical to be a municipal responsibility. Similarly, treating municipal wastewater to potable standard can be reasoned to be a municipal responsibility as wastewater treatment works are owned and operated by the municipality and in the case of Cape Town, these lie within the metropolitan boundary.

Cape Town remains committed to becoming a resilient city and is part of the 100 Resilient Cities Initiative. It is both prudent and appropriate for the City to take climate change risks into account in its planning. In line with international best practice thinking for coastal cities, Cape Town's resilience will be increased through the diversification of water supplies away from dependence on surface water only towards a situation where the City also obtains a share of its water from ground water, wastewater reuse and seawater desalination. Consequently, a resilient city will be able to both optimise and sustain water use through integrated management of four sources of water – surface water from rainwater (including urban storm water runoff) managed in dams and wetlands, ground water (with recharge), reused wastewater and desalinated sea water.

In developing the City Water Strategy, the City optimised the extent of the build programme as increasing the yield from the diverse sources will also increase the cost of water. In May 2018, calculations indicated a requirement in the region of 350MLD would provide assurance to 2028. The programme incorporated in the strategy is adaptable and will be continually reassessed in response to rainfall variability, augmentation progress and demand fluctuations. For example, experience with previous drought events in Cape Town and elsewhere show that droughts cause a structural downward adjustment in water demand over the medium and long term. It is anticipated that demand will readjust (after the end of the drought) to approximately 90% of the demand prior to the drought. Thereafter demand is projected to grow at the rate of up to 3% per annum to cater for population and economic growth.

AUGMENTATION: NEW WATER PROGRAM PROJECT STATUS

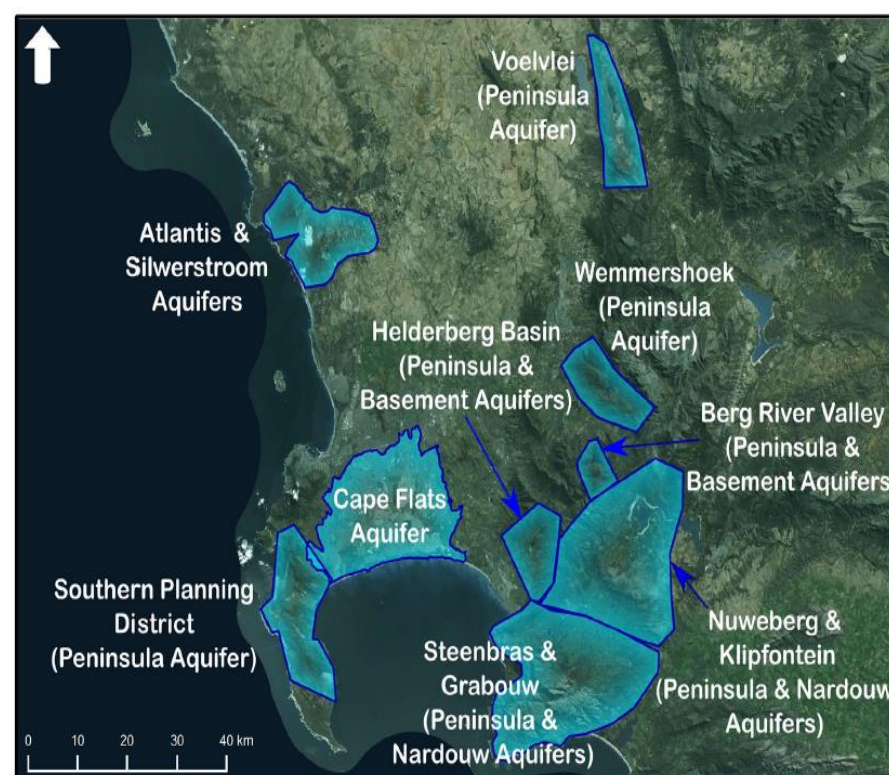
Since the second quarter of 2018, we have been working on the development of a City Water Strategy. The strategy is a culmination of everything we learnt during the drought, and particularly as it pertains to augmentation, detailed analysis, scenario planning and stress testing of a build programme to provide new and diversified water sources. The draft strategy will be published and in the public domain from mid- February 2019 for public participation, where after it will be amended as required, and submitted to Council for approval.

Progression of projects: The drought led to fast-tracking of a variety of projects with the aim of augmenting supply as quickly as possible, at reasonable cost to the City. Projects funded by the budget apportioned on the Section 29 report in November 2017 are in various stages of planning, design & implementation. As planning progressed, new information influenced priorities and decisions.

The drought disaster required project development to provide additional water in as short a space as possible. For example, on new groundwater projects exploratory boreholes informed the quality and quantity of water. If both the quality and quantity were acceptable, then production boreholes were drilled and the necessary infrastructure designed and installed to convey the groundwater into the reticulation system. If not, additional sites were identified for further exploratory boreholes to be drilled until the required yield was obtained. The scope of the augmentation projects continued to evolve and in so doing, became better defined. Costs and yields were expected to change until projects are finally commissioned.

SPRINGS & RIVERS:

- Consistent yield of **6.6 MLD** which increased during the rainy season. The springs utilized included Albion in Newlands and Main Spring which was reconnected to Molteno Reservoir in Oranjezicht which combined added approximately **1.5 MCM** to the system. Repairs undertaken to the Lourens River diversion weir added an approximate **0.9 MCM** which was treated at the Helderberg Water Treatment Plant above Somerset West.

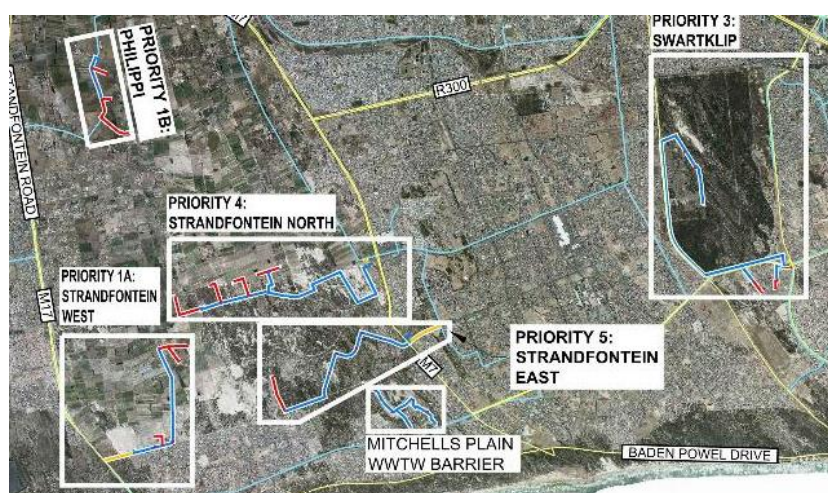
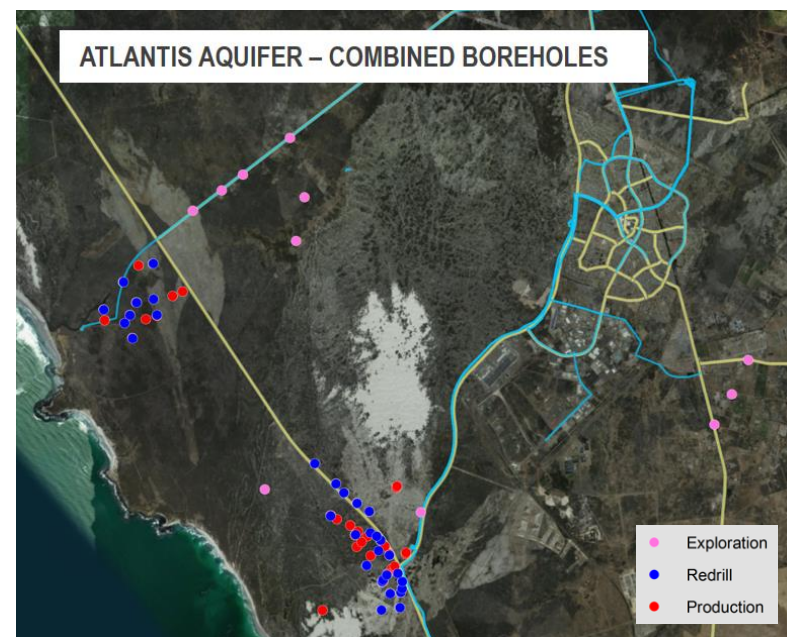


WATER TRANSFERS:

- Temporary transfers: The Groenland Water Users Association release of irrigation water stored in the Eikenhof Dam on the Palmiet River near Grabouw added approximately **7 MCM** into the Steenbras Upper Dam in the first quarter of 2018. The water transfer was facilitated by the DWS through the ESKOM Palmiet Hydroelectric Scheme.

GROUND WATER:

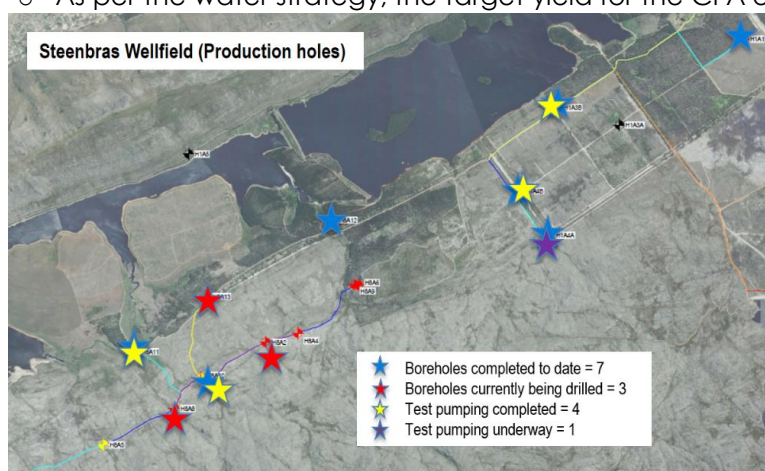
- Atlantis Aquifer:** Artificial recharge of the Atlantis aquifer began in 1979 when it was recognised that the naturally recharged groundwater yield of the aquifer was insufficient to meet the area's long-term needs. At the peak of the drought in 2018 Atlantis operated "off-grid" (separately from the wider western cape water supply system). The aquifer consists of unconsolidated dune sands with an average thickness of 25m. Natural recharge is augmented by artificial recharge through storm water runoff and treated waste water:
 - A sustained yield of **5-12 MLD** was achieved over the year:
 - By Aug 2017, 18 boreholes were in production with a cumulative yield of 12 MLD; and
 - By Apr 2018, 33 boreholes were in production with a cumulative yield capacity of 20 MLD with available boreholes pumping 24/7 (Witzands: ~16 MLD, Silwerstroom: ~4 MLD). Thus far, local demand has been sufficiently met with 14-16 MLD.
 - This also involved refurbishing of the existing wellfield infrastructure between November 2017 and June 2018;
 - Future refurbishments / expansions / optimisations in progress:
 - Expansion of Wellfields: Re-drilling old boreholes (September 2018 to June 2019);
 - Refurbishment of Witzands Water Treatment Works (July 2019 to June 2020);
 - Refurbishment of Silwerstroom Water Treatment Works (January 2019 to December 2019);
 - Expansion of Witzands Water Treatment Works (July 2019 to June 2021); and
 - Optimization of Artificial Recharge Infrastructure (July 2019 to June 2021).
 - Production was affected by operational issues at the softening plant inter alia. The Softening plant waste pond refurbishment tender is in progress.
- Cape Flats Aquifer (CFA):** The CFA stretches over nearly 400 km², from False Bay in the south to Tygerberg Hills in the north-east and Milnerton in the north-west. In some areas the groundwater is close to the surface resulting in wetlands while in the Philippi Horticultural Area small-scale farmers use relatively shallow boreholes to water their fields. In other places in the same region, the groundwater is situated at depths exceeding 200m metres below the surface. Aerial and land-based geophysical surveys were used to better determine the geological formation of the aquifer prior to exploratory drilling. As far as possible, borehole sites on City land were prioritised, in consideration of treatment required, anticipated yield and availability of receiving infrastructure. In general groundwater is not suitable for immediate human consumption and must be treated to potable standards before it enters the reticulation system. As a result, the CFA project was planned in clusters to optimise the number of treatment plants located, as well as the treatment processes necessitated by the water quality. What became apparent during drilling and testing over the past 12 months is that where yields were high, quality was poor and where yields were low, quality was better, resulting in higher costs per unit of groundwater. The sustainability of the Cape Flat Aquifer is very important to the long term water security of the City. This involves injecting treated waste water into the aquifer, as well as in future gathering storm-water into artificially constructed wetlands to filter down into the underlying geological formation of the aquifer. This recharge requirement is part of the license conditions from DWS and over time will increase the yield and improve water quality within the aquifer.



To date no water from the CFA has been fed into the reticulation system although much of the drilling is complete and treatment works as well as connecting infrastructure are under construction. The water use license allows for an abstraction limit of 20 Mm³ per annum in phase 1 (and 25, and 30 Mm³ per annum in phases 2 & 3 respectively). 20 Mm³ translates to a daily yield of 55MLD spread over the year, but infrastructure can be designed to provide for a peak yield to allow for higher abstraction over the summer months during periods of drought. The licence condition further provides for an annual recharge requirement of 12 MCM.

As part of the emergency augmentation programme, it was originally intended to fast-track the CFA to start producing potable water for augmentation by September 2018. Thanks to decent early rainfall in autumn of 2018, the emergency programme was re-assessed to provide better value for money given the considerable costs of development necessitated by the combination of yield and quality results. Once operational, actual volumes will be adjusted according to prevailing water requirements as treated groundwater is more expensive than surface water.

- Drilling progress as at end November 2018 – the total number of boreholes completed by December 2018 is 135 of 242 planned of which:
 - Exploratory holes: 46 of 51;
 - Monitoring holes: 48 of 55;
 - Re-charge holes: 1 of 55;
 - Production holes: 41 of 81;
- The completion of recharge injection wells is expected by Oct 2021. The duration at which extraction can continue, without recharge being required, will be determined through the modelling of how the CFA is responding to abstraction. This will therefore only be finalised at a later stage;
- As per the water strategy, the target yield for the CFA over the next 10 years is 20MLD starting in 2019 up to 48MLD by July 2020;



- Table Mountain Group Aquifer (TMG):** The TMG is thought to be the second largest aquifer in the world and consists of a number of aquifers that stretch from the Southern Peninsula to Grabouw and beyond. The City started investigating the aquifer in 2002 and first drilled exploratory boreholes in 2009. The nature of the TMG aquifer is such that artificial recharge is not required. The optimal locations for abstraction and input to the WCWSS lie close to dams and in other environmentally sensitive areas. The initial pace of development was predicated both by the high cost of development of a deep aquifer wellfield as well as environmental sustainability considerations. Hydrogeologists took a precautionary approach to determine the sustainable yield of the TMG Aquifer to prevent over-abstraction of groundwater and environmental damage.

During the drought it was anticipated that drilling of boreholes into the aquifer would take place in the dam basin of several of the dams including Steenbras and Theewaterskloof to allow the water from the boreholes to be pumped directly into the dams. As environmental interest

peaked while working around Steenbras Dam, the programme was reassessed and somewhat scaled down to provide the opportunity for further interaction and consideration of experience gained. Borehole placement was reviewed following environmental inputs which threatened to reduce the yield in the medium term considerably. The City established an environmental focus group with representation from Cape Nature, SANPARKS, DEADP, SANBI, as well as academics, consultants and other interested parties. The focus group developed a screening tool to assess borehole locations to ensure environmental impact is minimised at the various sites covered by water use licenses.

The TMG water use license covers a variety of different sites, and includes Steenbras, Wemmershoek, Bergriver, and Theewaterskloof as well as Cape Peninsula and Helderberg. Some of the boreholes are discharging pump test water into Steenbras although the volume is fairly insignificant (around 70 million litres at end November 2018).

○ **Steenbras borehole cluster (Phase 1):**

- 16 production boreholes will be incorporated into this wellfield with an expected yield of 15 MLD to 20 MLD by November 2019;
- A pre-treatment plant is in design;
- Progress to date:
 - 7 Production holes completed;
 - 3 Production holes in progress; and
 - Test pumping for 4 production holes completed and 1 underway.

○ **Nuweberg borehole cluster (Phase 2):**

- 14 production boreholes will be incorporated into this wellfield;
- Expected yield is 15-20 MLD;
- Pre-treatment of abstracted water will be required for this cluster which will feed to the Steenbras dam;
- Fieldwork to refine borehole siting; and
- Focus Group to evaluate borehole siting during January 20.

○ **Groenlandberg borehole cluster (Phase 3):**

- 13 production boreholes will be incorporated into this wellfield;
- Expect yield is 12 MLD; and
- Pre-treatment of abstracted water will probably not be required for this cluster which will feed to the Theewaterskloof dam.



TEMPORARY SMALL SCALE DESALINATION:

A maximum yield of 16 MLD is possible from the 3 plants developed. To date this has peaked at ~12 MLD with Monwabisi, Strandfontein and the V&A plants now operational. Water was first injected into the reticulation system in May 2018. The combined water production is shown here.

Strandfontein:

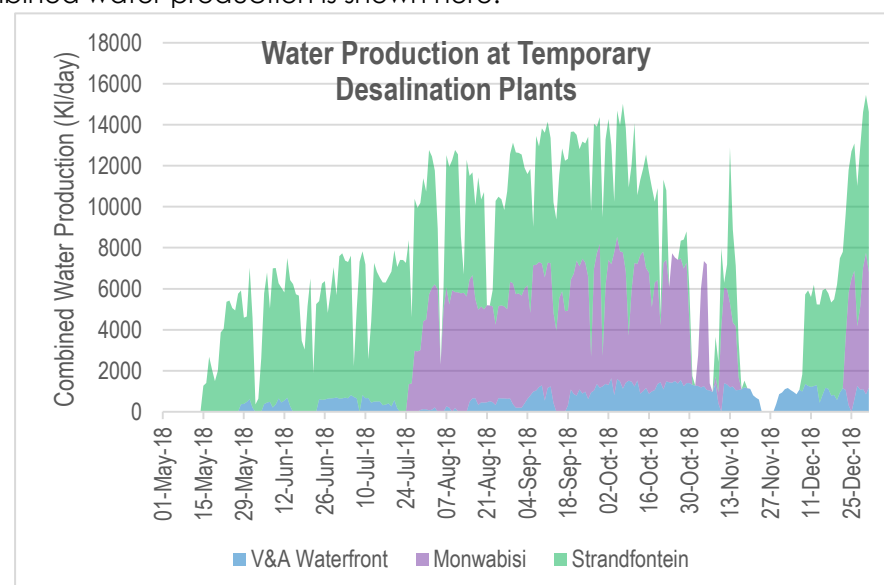
- First water delivered on 15 May 2018.
- Commissioned to full capacity (7 MLD) on 31 May 2018.
- Total water produced to date: over **0.88 MCM (880 ML)**.
- Major impacts on production due to high turbidity in the sea water caused by sea conditions (weather, big swell, etc.).

Monwabisi:

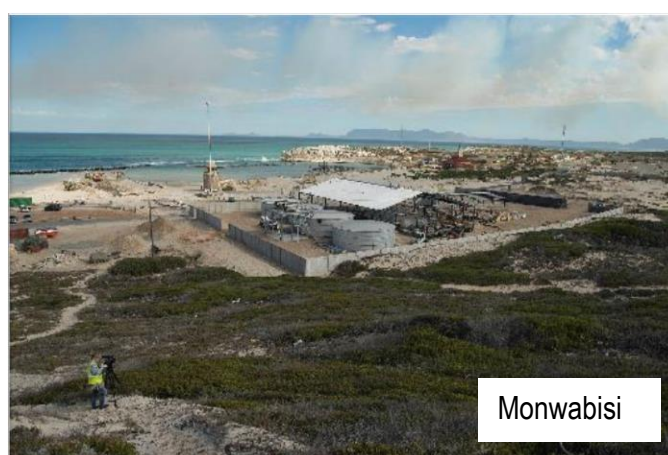
- First water delivered on 25 July 2018.
- Commissioned to full capacity (7 MLD) on 21 Sept 2018
- Total water produced to date: over **0.55 MCM (550 ML)**.
- Major impacts on production:
 - Electrical interruptions (cable theft); and
 - High turbidity in the sea water caused by sea conditions (weather, big swell, etc.).

V&A Waterfront:

- First water delivered on 28 May 2018.
- Commissioned to full capacity (2 MLD) on 05 Sept 2018
- Total water produced to date: over **0.13 MCM (128 ML)**.
- Major impacts on production:
 - Network pressures; and
 - Sea water turbidity issues.



Strandfontein



Monwabisi



V&A

PERMANENT DESALINATION AT SCALE: The City concluded a feasibility study on a large scale desalination plant early in 2015. Lessons from the drought have influenced the original planning incorporated into the Water strategy.

- The Site Selection Investigations (Phase 1: Preliminary Investigations) for the siting of a 100-150MLD Permanent Desalination plant were initiated in September 2018. The purpose of the study is to conduct the required investigations for the decision making around the positioning of a Permanent Desalination Plant in the Cape Town area.
- Preliminary assessments are currently being conducted which includes:
 - Land & Zoning assessment;
 - Bulk Water Infrastructure assessments;
 - Bulk Electrical Infrastructure Assessments;
 - Sea Water Quality Analysis;
 - Marine investigations; and
 - Preliminary Environmental screening.

RE-USE:

The introduction of more expensive water such as ground and desalinated water necessitates maximising value by re-use. We are committed to maximizing the re-use of wastewater in line with the National Water Resource Strategy (2013) to meet current and future water demand. At present some 8% of treated

Zandvliet temporary re-use: This scheme was part of the Section 29 projects funded in Dec 2017 and was due to be completed towards the end of 2018.

Target Yield for the scheme is **10MLD** by June 2019.

- Bulk Earthworks and Tanks:
 - Platform was completed on 05/11/2018; and
 - Tanks are in advanced stage of installation on site.
- Internal Pipelines and Chambers:
 - Anticipated completion date is extended to mid-February 2019 due to existing services on site requiring relocation and repairs.
- Plant:
 - Target commissioning date is March 2019;

wastewater is used for industrial, commercial and landscaping purposes. A very small volume is also used in combination with stormwater to recharge the Atlantis Aquifer and maintain the sea water intrusion barriers associated with the groundwater scheme. Future plans include use of treated wastewater to recharge the Cape Flats Aquifer and as a direct source of drinking water to be blended with water supplied from the Faure Water Treatment Plant which serves a large part of the municipal area. This is in keeping with our objective of creating a water sensitive city which seeks to maximize integration of the urban water cycle to build resilience and protect our sensitive natural ecosystems. This approach is successfully implemented elsewhere. During the height of the drought, a 10MLD temporary re-use project at Zandvliet was triggered.

Faure New Water Scheme: This project is being designed to provide 70MLD (expandable to 100MLD) of re-use water from Zandvliet & potentially Macassar Wastewater Treatment Works into the raw-water supply to Faure water treatment works. Target Yield for the scheme is **70MLD** by January 2023.

- Project is currently in the planning, design and investigation phase;
- The production of potable water is dependent on the completion of planned upgrades to the Zandvliet WWTW. Two Zandvliet WWTW upgrade contracts have been awarded and the remaining two should be awarded in April 2019;
- The required site investigations, sampling and analyses are underway;
- Planning for Stormwater Management in progress for Zone 1 and 2;
- Power supply options are being investigated;
- WULA to be submitted by end of 2018;
- Geotech complete for Zone 1 and 2, in progress for pipelines;
- Draft Preliminary Design Report has been submitted to the City for feedback;
- International peer review was done and response received in Dec 2018;
- Public engagement process proposal submitted to the City and requires finalising.

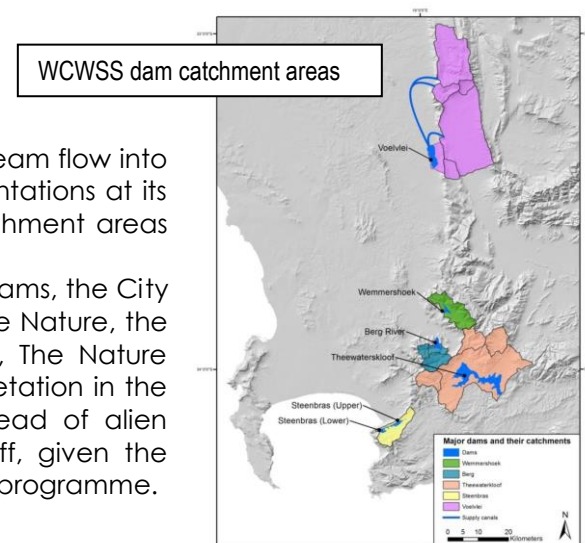


Additional surface water ±60MLD confirmed: DWS is undertaking preparatory work for the augmentation of Voëlvlei Dam from the Berg River catchment (winter flow) downstream of the Berg River Dam. Preliminary designs are complete and the EIA started in November 2015. The project is due for completion by the end of 2021 (with construction to commence in 2020).

- The following other surface water augmentation options could be considered by DWS as part of their longer term planning:
 - Michell's Pass diversion weir (upper Breede) to augment Voëlvlei Dam;
 - Further Phases of the Palmiet River (incl. the raising of Steenbras Lower Dam);
 - Building a new dam in the Molenaars River (Worcester side of the Huguenot Tunnel);
 - Raising the structure of Voëlvlei Dam.

Clearing alien vegetation: The City is committed to dealing with the spread of alien vegetation which reduces stream flow into the main water supply dams. The City is continuing with projects aimed at removing the last remaining pine plantations at its Steenbras and Wemmershoek Dams as well as the eradication of other alien vegetation within mountain catchment areas under its direct control.

As the majority of dense alien infestations are situated in the headwaters of the Theewaterskloof and Berg River dams, the City is actively bringing together a wide range of role players including both government departments such as Cape Nature, the Departments of Environmental Affairs and Water & Sanitation and private sector partnerships such as WWF, The Nature Conservancy which has established The Greater Cape Town Water Fund to help fund the removal of alien vegetation in the catchments of this region. The objective is to formulate and implement long term plans to arrest the spread of alien species over the next 10 years. The City intends funding alien clearing programmes through the water tariff, given the anticipated water supply benefits. Significant ecological and socio-economic benefits will also be realised by the programme.



(Steenbras catchment after fires in January 2019)

The Water Outlook of May 2018 included an Annexure on **Cape Town's New Water Augmentation Programme – an overview**. The most relevant sections have been copied here to provide the necessary background on how the New Water augmentation programme was developed.

How much additional water is needed?

The quantity of additional supplies needed to achieve a secure supply depends primarily on a decision on risk appetite and on assumptions related to the future probability of rainfall distribution and demand. Detailed modelling has been undertaken based on the available historical rainfall records, hydrological modelling and climate change forecasts. This is captured in the Draft Water Strategy, out for public participation from February 2019.

The modelling, and analysis of scenarios based on this modelling, shows that, using a stochastically-generated set of rainfall patterns based on past rainfall records, and assuming a 1 in 200 level of assurance, an augmentation of 50 to 100 MLD would currently (2018) be sufficient (to meet demand and then growing at 30 MLD per annum thereafter). As we do not have current augmentation of this scale in place, we are working on the medium term, requiring new water augmentation of approximately 350 MLD to keep dam levels above restriction levels at the end of summer, providing a margin of safety. Any augmentation over and above this would increase levels of assurance and result in 'surplus water' through more frequent dam spillages during winter. This is a risk averse view that will give the City of Cape Town a higher level of assurance of supply and will prevent the kind of restrictions currently being experienced from being implemented again in the foreseeable future.

COST CONSIDERATIONS

The actual costs and yields of any water augmentation scheme is only accurately known after the project has been commissioned. Until that time, reliance must be made on comparable experience with similar projects elsewhere, together with engineering estimates for the specifics of the proposed project.

Desalination costs are primarily a function of scale, water salinity quality and temperature, marine works requirements, network integration costs and procurement methodology. The optimum scale for sea water desalination is in the range of 50 to 150 million litres per day. Both smaller and larger plants suffer from diseconomies of scale. Expensive marine works involving tunnelling increase costs substantially and should be avoided where possible. Project costs are also a function of procurement method. Well-managed procurement, attracting reputable international companies, and contracted through a build-operate-transfer contract has delivered desalinated water at less than US\$1 (R12) per thousand litres in many places. In contrast, projects contracted through an owner-engineer design-build model are exposed to cost escalation and have proved to be more expensive, with costs in the range of \$2 to \$3 per thousand litres. An appropriate comparison for an understanding of the different cost outcomes between these two procurement models is the difference in the cost outcomes between the owner-engineer model Eskom adopted for the Kusile and Medupi power stations (both of which experienced massive cost escalations) and the Renewable Energy Independent Power Procurement Programme (REIPPP), which has delivered cost-efficient coal, wind and solar power through competitive bidding processes linked to power purchase agreements. In the case of a 150 million litre per day desalination plant, the difference in cost outcomes between \$1 (R12) and \$2-3 (R24-36) per thousand litres results in additional "inefficiency" costs of R0.65-1.3 billion per annum, or R6.5-13 billion over ten years. Achieving cost-efficient outcomes for the development of desalination capacity is therefore very important.

Wastewater reuse is expected to be less costly compared to desalination because the capital costs are lower (no expensive marine works are needed) and energy costs are about half of that needed for desalination – 2 kWh for reuse compared to 3.5-4 kWh for desalination per thousand litres. Scale is reasonably important for wastewater reuse too. For example, a single wastewater reuse treatment facility for 50 million litres per day is about 15% cheaper than a 20 million litres per day facility, and a single combined facility of 70 million litres per day is strongly preferred for operational reasons and is cheaper compared to two separate facilities.

Ground water. Ground water is cheaper than wastewater reuse because both the capital and operating costs are lower. The technology required is simpler and the energy requirements are much lower. Costs are sensitive to water quality (and hence the required treatment costs) and the infrastructure costs are related to borehole depth, yields and location. Cape Town has successfully developed a sandy aquifer ground water scheme, with recharge, in Atlantis and Silverstroom, with a yield of 12 million litres per day.

Surface water. Surface water schemes are cheaper than the other sources of water. The average cost, including bulk infrastructure and treatment, is about R5 per thousand litres. For this reason, preference has been given historically to surface water schemes. In fact, the Western Cape Water System is almost exclusively dependent on surface water.

TIMING CONSIDERATIONS

The complexity and logistical implications of project implementation differ depending on the source of water and technology employed. This affects the implementation time frames from the time a decision is made to proceed. Indicative target timeframes are shown, based on international experience. In principle, ground water projects should be fastest to implement, then re-use and then desalination, based on project complexity and logistical requirements. However, the actual timeframes are dependent on regulatory requirements as well as the approach to procurement that is adopted. In South Africa, the regulatory requirements are both complex and lengthy. This, together with stringent public procurement regulations, means that a moderately large infrastructure project that is procured in the standard way (through an owner design-build model) is more likely to take four to five years to implement rather than the two to three years shown for re-use and desalination.

ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

The development of water resources, no matter what the source, has some environmental impacts. Large surface water schemes involve the construction of dams (often in environmentally important or sensitive areas such as mountainous wilderness areas) and associated infrastructure, including long pipelines, pump stations etc. Desalination is energy intensive, with a large carbon footprint if reliant on coal-based electricity, and the discharge of brine (and the related marine works) may affect sensitive coastal areas. The treatment of wastewater for reuse also uses energy (though less than desalination) and will involve infrastructure development (treatment works and pipelines). The flow of wastewater to riverine environments and wetlands will be reduced. Groundwater abstraction, provided it is not over-abstracted, has the least environment impact compared to the alternatives. The terrestrial impact is low, with a very low footprint, especially compared to surface water schemes. Sustainable ground water yield is regulated through a licencing system, together with monitoring, and can be managed through groundwater recharge from rainfall, stormwater systems and treated wastewater.

WHAT IS AN APPROPRIATE MIX AND SEQUENCING OF 'NEW WATER'?

Because desalination is the only truly climate resilient source of water that is independent of rain, there is a strong argument to be made that desalination should be a component of Cape Town's future source of water supply. However, desalinated water is the most expensive and is likely to take longer to implement than the alternatives. For these reasons, Cape Town should not rely on desalination as the only alternative source of water. Ground water is faster to implement, compared to permanent desalination (at scale) and is also much cheaper. Ground water has a lower environment impact compared to the alternatives. Importantly, groundwater can be managed as a form of water storage through recharge and without evaporation losses. This means ground water is a very sustainable source of water that can help mitigate drought events. On these grounds, the prioritisation of ground water as a means to diversify Cape Town's water supply is compelling. In this light, Cape Town has already committed itself to developing the Cape Flats, Atlantis and Table Mountain Group aquifers. Reuse is both cheaper than desalinated water and should be quicker to implement because the logistical requirements are less onerous and complex. There is therefore a compelling argument to include reuse as part of the diversification of Cape Town's water sources.

It is accepted that it is appropriate to get water from all three sources – ground water, wastewater reuse and sea water desalination – to ensure Cape Town is resilient to future water climate change or shocks. The volume of how much to obtain from each source is dependent at least in part on how quickly significant yields can be abstracted into the system.

- In summary, the City prioritised the following interventions during the drought:
1. Continued **demand management** initiatives to reduce dam drawdown (in line with NDWS restrictions);
 2. Managed and monitored **dam behaviour**;
 3. Fast-tracked **augmentation**:
 - **Decisions** under consideration by the City on **optimal augmentation** types, volumes, methods;
 - **Groundwater** projects (Atlantis, Cape Flats and TMG Aquifers) have been prioritised;
 - **Aquifer recharge** projects from treated wastewater under development;
 - **Long-term Permanent Re-use** project under development;
 - **Long-term Permanent Desalination** under evaluation in terms of siting, optimum yield & procurement method;
 4. Managed financial impacts through appropriate adjustments to the **tariff structure** and level;
 5. Endeavoured to improve
 - **coordination** and leadership within and between spheres of government;
 - information flows and consistency of messaging; actively **engage citizens** and stakeholders to encourage active citizenry and stakeholder partnerships to jointly solve problems.

In closing, thank you to all Capetonians, households and businesses, for reducing consumption so dramatically to win Cape Town the title of the best water saving city in the world. Thank you to all the consultants and contractors procured by the City in its endeavours to communicate, to reduce demand, and to fast track new supplies. Thank you also to the World Bank, USAID WASH-FIN, National Treasury, the Presidential Infrastructure Coordinating Commission and the Cities Support Programme for sponsoring and providing subject matter experts to work with the City and advising on how best to navigate the drought.



(Photographs courtesy of Bruce Sutherland)

ⁱ <https://edition.cnn.com/2018/02/05/africa/cape-town-day-zero-intl/index.html>
ⁱⁱ <http://www.capetown.gov.za/Family%20and%20home/residential-utility-services/residential-water-and-sanitation-services/this-weeks-dam-levels>
ⁱⁱⁱ <https://awwa.onlinelibrary.wiley.com/doi/abs/10.1002/awwa.1154>