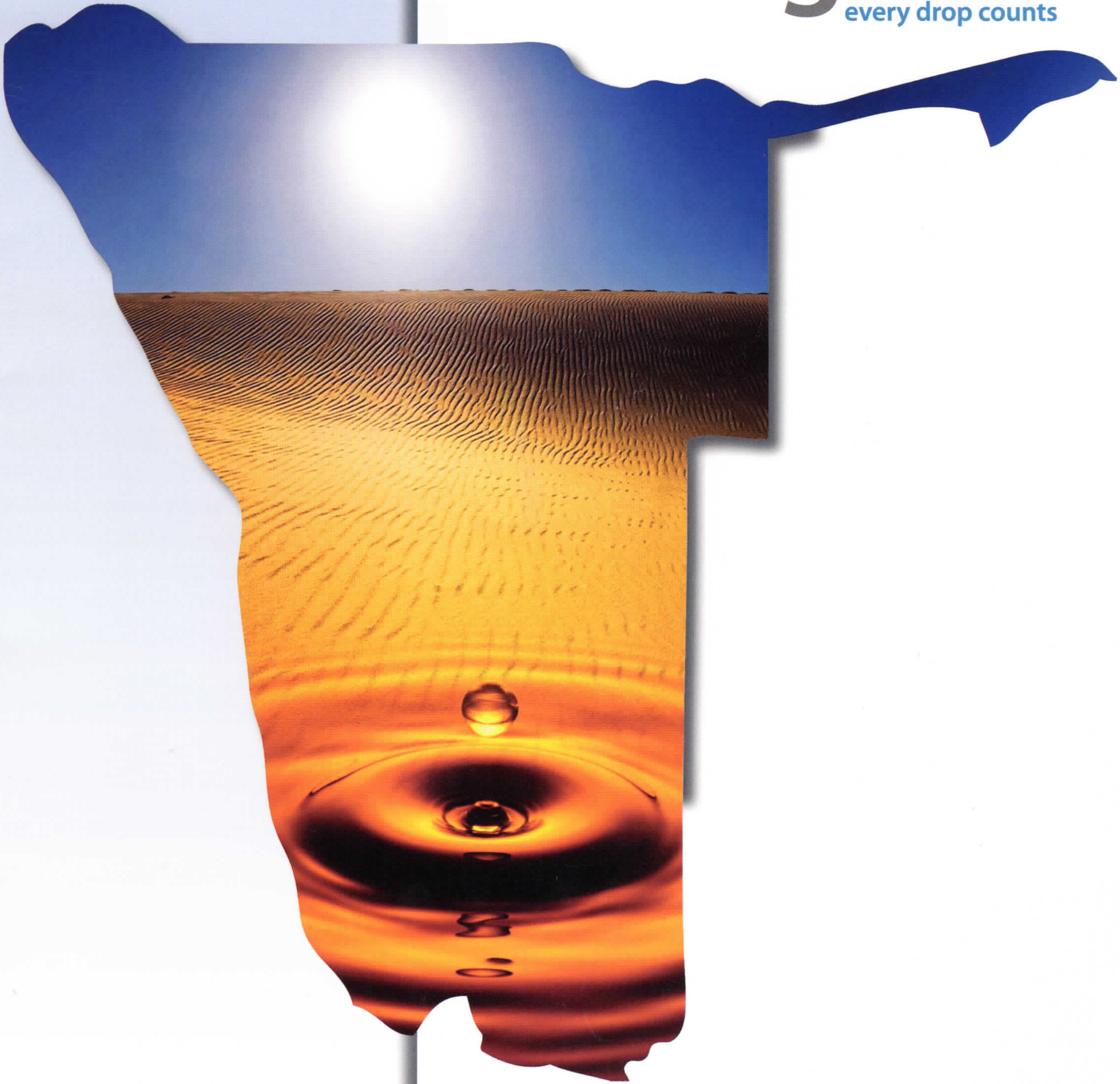
wingoc
every drop counts



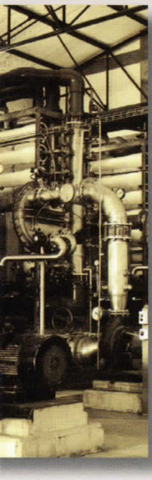
NEW GOREANGAB WATER RECLAMATION PLANT

THE NEW GOREANGAB WATER RECLAMATION PLANT

History and Background

Namibia is the most arid country in Southern Africa. Windhoek, the capital of Namibia, has an average annual rainfall of around 370mm, while the average evaporation rate is 340 mm. The nearest perennial river, the Okavango, is situated 700 km away from the city on the North-eastern border of the country. Windhoek is therefore continuously facing serious water challenges.

In 1968 the Goreangab Water Reclamation Plant was built by the City of Windhoek to reclaim water directly from domestic sewage effluent. Over the past 30 years the process was improved and the plant capacity extended to 2.9 Mm^3– per annum. Due to the fact that all naturally available water sources in and around Windhoek have been fully harnessed, the New Goreangab Reclamation Plant was completed in 2002 and comprises the latest available proven water treatment technology. This was done in order to ensure the total utilisation of available effluent from domestic wastewater to ensure the security of water supply for the future. The new plant has been based on extensive experience (30 years), research done locally, and on input from international experts to assure the compliance to the strictest water quality guidelines and parameters applied internationally.

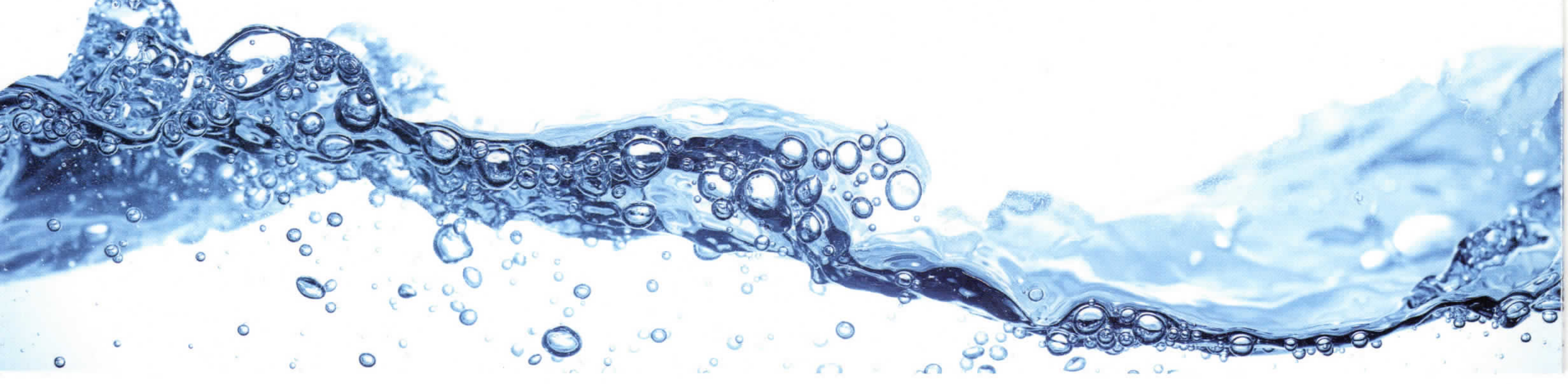


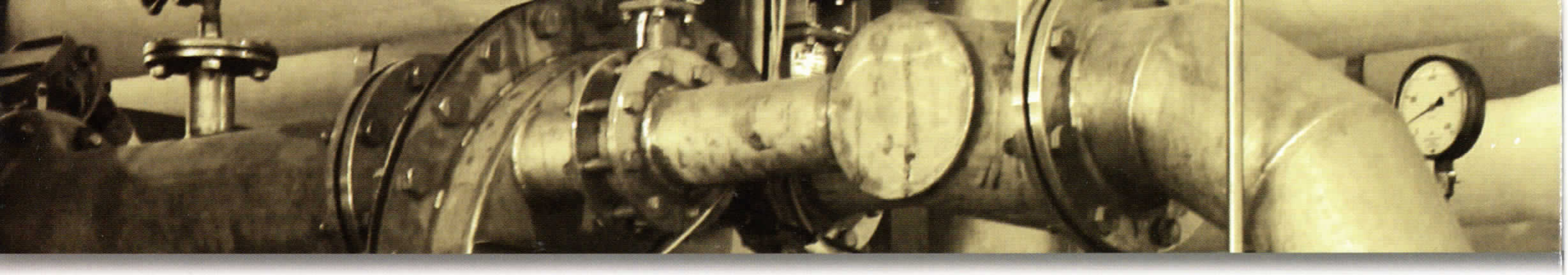
Direct Water Reclamation

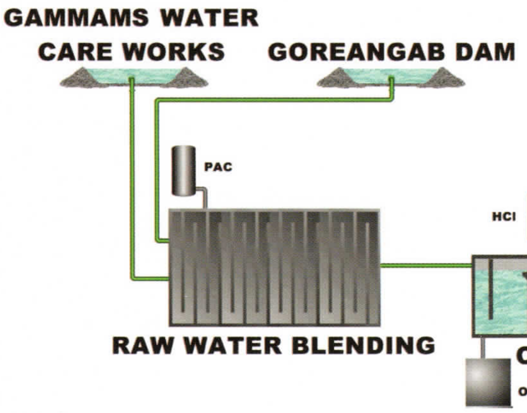
Successful direct reclamation as practised in Windhoek is based on the practice of diverting industrial and other potentially toxic wastewater from the main domestic sewage system. The domestic wastewater is treated to produce an effluent of adequate and consistent quality, which is further treated to produce safe potable water. In addition, it is important to continuously maintain a multiple-barrier treatment sequence as a safeguard against pathogens and other potentially harmful and unwanted contaminants. Intensive bio-monitoring programs and other tests are carried out on reclaimed water, and no negative health effects have been detected as a result of the use of reclaimed water since 1968.

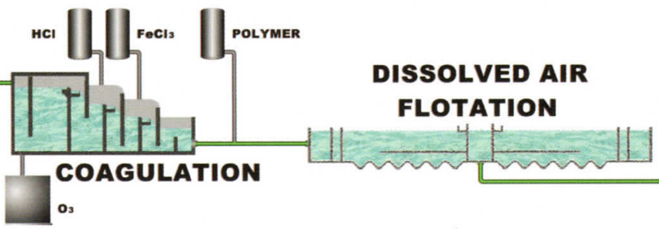
In order to ensure successful direct reclamation, the multiple-barrier concept needs to be followed. This multiple-barrier approach ensures that at least two (in many cases three and more) effective removal processes are in place for each crucial contaminant that could be harmful to human health or aesthetically objectionable.

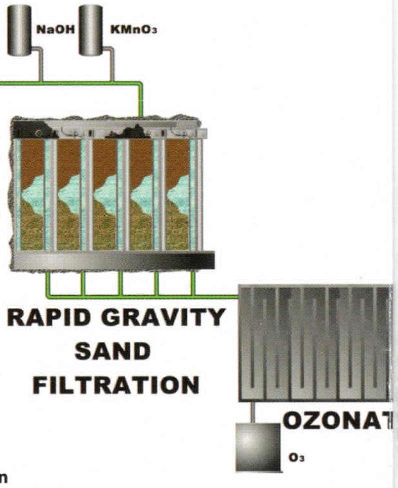
• • • EXCELLENCE THROUGH CONTINUOUS IMPROVEMENT











1. Raw Water Blending and Powder Activated Carbon Addition

Water from two water sources can be utilised for production. They are semi–purified waste water and Goreangab Dam water. Either water source or a mixture of the two can be used for reclamation to potable water. Powder activated carbon can be added to the raw water for the removal of dissolved organic compounds.
A total flow of 1100 m^3/h can enter the plant.

2. Pre-oxidation and Coagulation

The combined raw water feed line splits into two separate lines, each in turn feeding into the stilling chamber of the pre-ozonation section.
The main functions of the Ozonation (O3) section can be summarised as follows:
1) Flow stilling and equal division of the feed into two trains.
2) Pre-ozonation assists micro–flocculation, dissolved organic carbon (DOC) oxidation, iron and manganese oxidation, oxidation of substances such as sulphites and nitrites, colour removal and so forth.

The flash mixing section consists of the following process steps:
1) Chemical dosing of Hydrochloric Acid (HCl) for pH correction, Ferric Chloride (FeCl3) as primary coagulant, and polymer as coagulation aid (if required).
2) Two stages of flash mixing to form micro particles (floc forming).

The coagulation process is based on the destabilisation of colloidal particles (suspended solids) in water. The particles have the same charge and therefore naturally repel each other and should therefore be destabilised in order to promote the formation of flocs.

Ferric Chloride is added to promote particle destabilisation and particle aggregation. Particle aggregation is enhanced in the flocculation stage.

A polymer can be added as coagulant aid in combination with Ferric Chloride. Synthetic organic polymers can enhance particle aggregation and produce larger, stronger, and/or denser flocs that will be more readily removed in the downstream flotation process.

3. Flocculation

Gentle agitation is required so that the micro particles, which were formed during flash mixing, can agglomerate into macro particles. During this step the water is stirred very slowly which causes small particles to grow to bigger particles, also called floc.

4. Dissolved Air Flotation

Suspended solids are removed in the DAF units in the form of light particles or flocs. The bulk of the particles will be floated to the surface and periodically removed. The DAF units have also been provided with sludge hoppers and a desludging system to remove accumulated sludge. The latter could occur during the rainy season when higher silt loads in the Dam water are expected.

Flotation of floc and other suspended particles (e.g. algae) is achieved by bringing the flocculated water into contact with microscopic air bubbles. The bubbles adhere to the flocs, which then rise to the surface to form a scum layer. The latter is periodically, hydraulically removed.

Two independent, rectangular, horizontal-flow DAF units, each consisting of two flotation sections, are provided. The maximum hydraulic load in any DAF unit will be 4 m/h.

Air–saturated Water Production

Filtered water from the constant level head tank is used to produce air saturated water ('white water').
To produce the fine air bubbles, air is dissolved in water in a saturator vessel under elevated pressures. The water is then mixed/released into the flocculated water and the reduced pressure results in fine bubbles being released.

5. Rapid Gravity Sand Filtration

Prior to sand filtration, Caustic Soda (NaOH) and Potassium Permanganate (KMn04) are added to the partially cleaned water to facilitate the oxidation and precipitation of dissolved Iron (Fe) and Manganese (Mn) in the filter bed. Iron and Manganese removal is important as it causes the discolouration of potable water, which is aesthetically unacceptable to consumers.
The main functions of the sand filters are to remove the remaining suspended particles in the partially cleaned water. This includes the partial removal of microorganisms such as algae and pathogens.

Dual media filters are physical barriers and become clogged with particles after several hours of operation. It is therefore necessary to clean the filters periodically by backwashing with clean process water. The resulting heavily polluted backwash water is discarded by releasing it to a nearby wastewater treatment plant.

Type:	Single bed, false floor
Dimensions:	12,6 m long x 3,0 m wide
Filter feed:	226 m^3/h per filter
	1 130 m^3/h total (incl DAF recycle flow)
Filtration area:	37,8 m^2 per filter
	189 m^2 total
Filtration rate:	5,98 m/h
Filter media:	Dual media, hydro–anthracite and sand

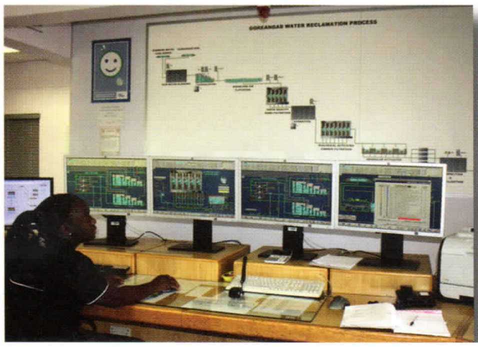
6. Ozonation

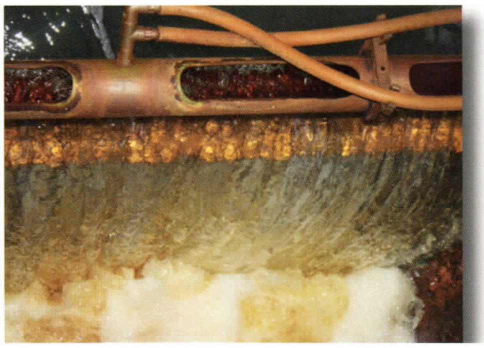
High purity Oxygen gas (91 to 93%) is used for the generation of Ozone (03), which is a very powerful oxidant. Three Ozone generators are provided to produce Ozone for main and pre–ozonation. The largest portion of the generated Ozone is used for Main Ozonation. Ozone gas is injected into the filtered water to oxidise non–biodegradable dissolved organic compounds to biodegradable dissolved organic compounds and for the inactivation of viruses and parasites (Giardia and Cryptosporidium). The more biodegradable oxidised organic compounds are taken up by microorganisms in the next process step.

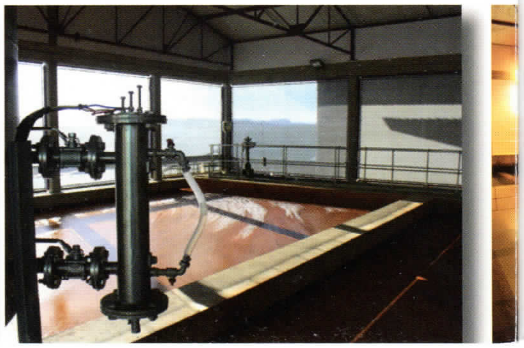
The principal objectives of Main Ozonation are:

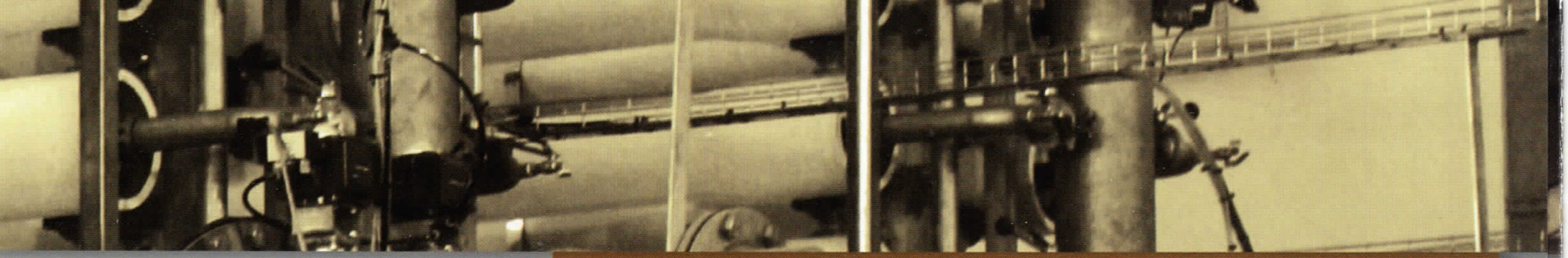
Oxidation of organic compounds to more easily biodegradable substances (partial conversion of COD to BOD)
Partial reduction of DOC to BDOC
Oxidation of Iron and Manganese
Bacterial disinfection: Inactivating of viruses and parasites for example Cryptosporidium

Main ozonation consists of a tank divided into three sections, each consisting of a contact chamber and reaction chamber. Because of the long hydraulic retention times (CT = 20 minutes) in the structure, Ozone can be injected according to the Ozone demand at three different points.
After Ozonation an automatically controlled Hydrogen Peroxide (H_2O_2) dosing system is provided to destroy any residual Ozone after the third stage of main ozonation in order to protect the microorganisms in the next process step.









NEW GOREANGAB WATER RECLAMATION PROCESS

7. Biological Activated Carbon Filtration (BAC)
Activated carbon filters are provided to reduce the concentration of various organic constituents in the water after Ozonation. BAC filters are provided to reduce the overall GAC saturation in the plant by utilising microorganisms to reduce the organic loading. Most of the organic constituents will be in an easily biodegradable form after oxidation in the Ozonation step upstream of the BAC filtration step.
The BAC filters are periodically backwashed to remove excessive microorganisms. The backwash water is recycled.

Type:	Single bed, false floor
Dimensions:	9, 1 m long x 2, 5 m wide
Filter feed:	146 m^3/h per filter normal
	204 m^3/h per filter maximum
	1 021 m^3/h total feed
Filtration area:	22, 75 m^2 per filter
	159, 25 m^2 total area
Filtration rate:	6, 4 m/h normal
	9, 0 m/h maximum
EBCT:	14 minutes normal
	10 minutes minimum
Bed depth:	1, 5 m

8. Granular Activated Carbon Adsorption (GAC)
After BAC filtration, product water gravitates in a distribution channel to the GAC filters. The double bed GAC filters will always be operated in an upflow/downflow arrangement, without movement of Carbon from one filter bed to the other. The first stage (upflow filter) is used as the roughing filter, removing the bulk of the organic matter, while the second stage (downflow filter) is the final polishing stage. The remaining dissolved organic compounds in the water are adsorbed by the granular activated carbon to produce water with limited concentrations of dissolved organic compounds.

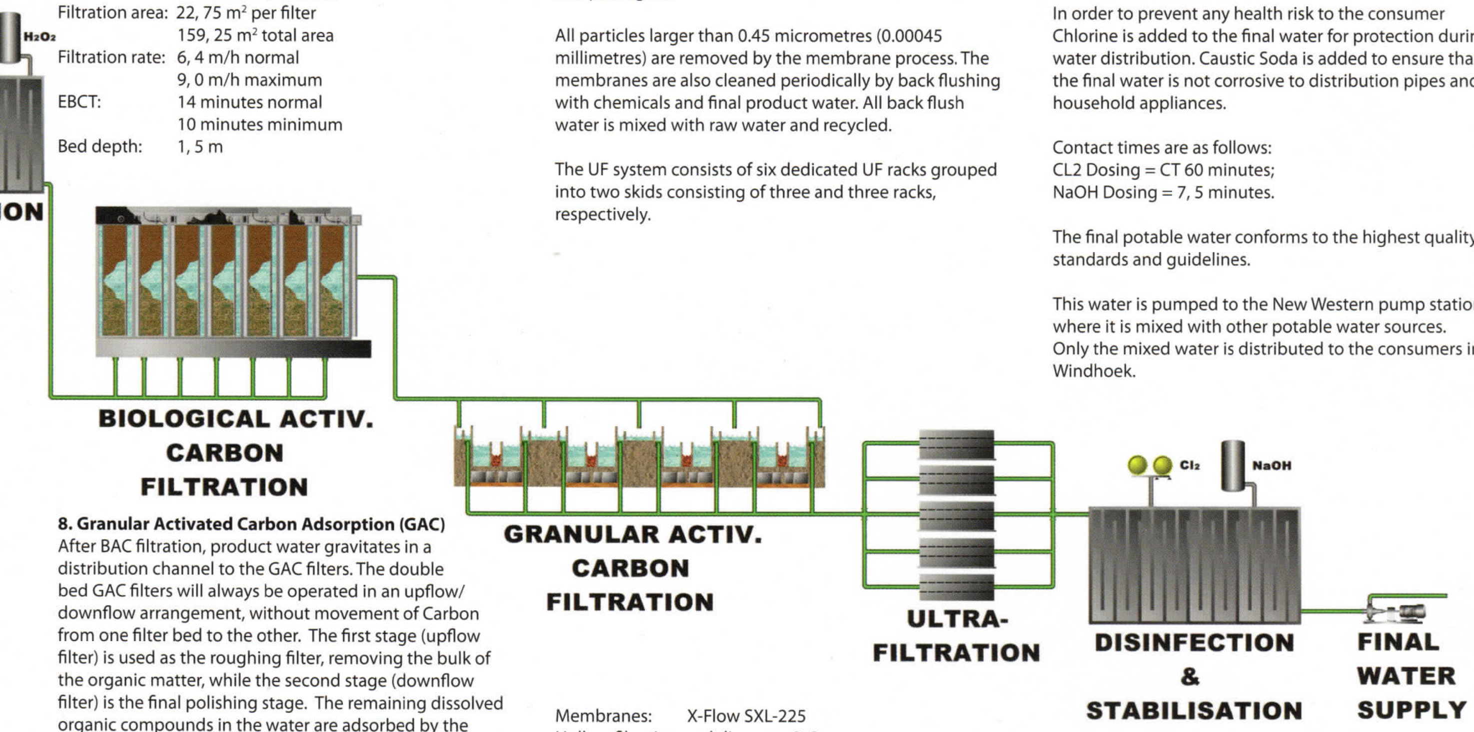
GAC adsorption is used for removal of dissolved organic compounds, colour, and taste– and odour causing compounds still present in the water after ozonation. Generally, high molecular weight, non–polar compounds are adsorbed more effectively than low molecular weight, polar compounds.
The production of potable water with no or very low concentrations of dissolved organic compounds is important to prevent the formation of disinfection by–products which could be detrimental to human health.

Type:	Double bed, false floor
Dimensions:	9,1 m long x 2,5 m wide (1 off bed)
Filter feed:	144 m^3/h per filter normal
	202 m^3/h per filter maximum
	1 021 m^3/h total
Filtration area:	45,5 m^2 per filter
	318,5 m^2 total
Filtration rate:	6,4 m/h normal
	9,0 m/h maximum

9. Membrane Filtration
The ultra–filtration plant will polish the product water and serves as the final barrier against biological and micro–biological contaminants. Ultrafiltration membranes are used as the final polishing step for the removal of all remaining suspended particles such as bacteria, viruses and pathogens.

All particles larger than 0.45 micrometres (0.00045 millimetres) are removed by the membrane process. The membranes are also cleaned periodically by back flushing with chemicals and final product water. All back flush water is mixed with raw water and recycled.

The UF system consists of six dedicated UF racks grouped into two skids consisting of three and three racks, respectively.



Membranes:	X-Flow SXL-225
Hollow fibre internal diameter 0, 8 mm	
Permeate flow:	220 m^3/h nominal (per rack)
	1320 m^3/h nominal (total)
	1440m^3/h maximum
Permeate flux:	99 l/ (m^2/h) net*
Pressure vessels:	14 per rack
	84 total
Plant lay out:	4 off 1,5 m long membranes modules in 8 inch pressure vessels, 6 meters long each

10. Balancing Reservoir
Permeate from the membrane racks is pumped into a common header that discharges into the Balancing Reservoir.

The water is further disinfected with Chlorine gas. The Balancing Reservoir capacity is 10 ML, and serves as a Flow stabilisation for the Clear Water Reservoir and emergency Water Supply for the Windhoek Water Reticulation System.

11. Disinfection and Stabilisation
The Chlorine contact and stabilisation tank receives permeate from the Balancing reservoir. The final product water is prepared for blending with other potable water sources by adding Chlorine (Cl2) for disinfection and Caustic Soda (NaOH) for pH correction and stabilisation.

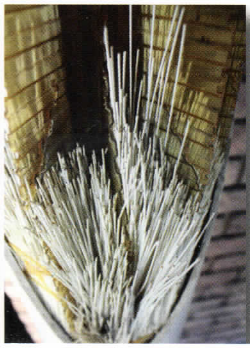
In order to prevent any health risk to the consumer Chlorine is added to the final water for protection during water distribution. Caustic Soda is added to ensure that the final water is not corrosive to distribution pipes and household appliances.

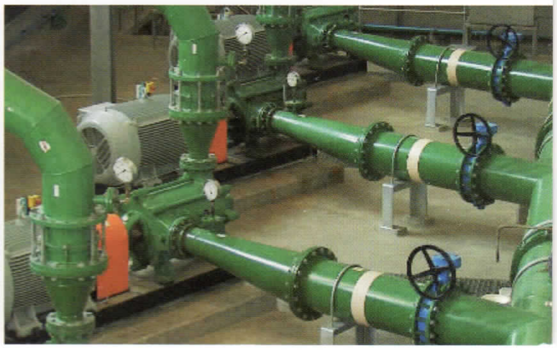
Contact times are as follows:
CL2 Dosing = CT 60 minutes;
NaOH Dosing = 7, 5 minutes.

The final potable water conforms to the highest quality standards and guidelines.

This water is pumped to the New Western pump station where it is mixed with other potable water sources.
Only the mixed water is distributed to the consumers in Windhoek.

All the wastewater from the plant is collected in the waste sump. The sump capacity is 300 m^3.
As wastewater is discharged into this sump, it gravitates to the Otjomuise Water Care Works.





CLEAN DRINKING WATER SHOULD NOT BE A MIRAGE. BUT A REALITY

Quality and Risk Assesment

The water quality is measured against the World Health Organisation Guideline, Namibian Guideline for Group A Water and South Africa Water Standards. During the 24 hour production process water samples are taken on a four hourly basis after each treatment process for analyses in the WINGOC laboratory.

Contractual refrigerated composite samples are taken twice per week after each treatment process and these samples are comprehensively analysed for all water quality constituents.

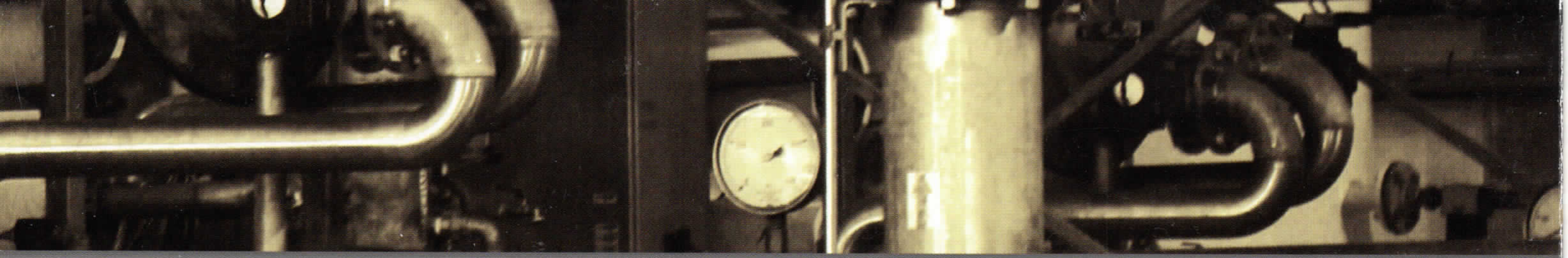
Public Acceptance

Since the inception of direct reclamation in 1968, no known water related outbreak of diseases was experienced. Haussmann (1983) summarised public opinion as follows: "The Windhoek citizens always fully appreciated and supported the scheme, even with some civic pride". Over a period of 32 years, this public trust was established and WINGOC together with the City of Windhoek will continue this tradition.

Conclusions

Potable reuse, despite its potential difficulties, is an indispensable element of the Windhoek water system and has proven to be a reliable and sustainable option. The Windhoek experience with wastewater reclamation to potable drinking water standard has been an unqualified success since 1968. This is of great significance to Southern Africa and other arid regions of the world as it demonstrates that:

- With proper care and diligence, water of exceptional quality can be consistently produced from domestic wastewater,
- If properly informed, consumers can fully accept this perhaps controversial option,
- The cost of reclamation in Windhoek is still lower than the cost of transporting water from distant sources (Okavango River),
- Wastewater reclamation is a practical option, not only for technologically advanced countries, but also for other regions.



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Windhoek Goreangab Operating Company (Pty) Ltd

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