EXECUTIVE SUMMARY

BACKGROUND

South Africa has a low rainfall with an annual average of 497 mm which is well below the world average of 860 mm (Anon, 1986a).

The ever increasing demands for fresh water have placed a severe strain on the available water resources. The estimated total annual water demand in South Africa is expected to exceed $22 \times 10^9$ m$^3$ by the year 2000 of which about $5 \times 10^9$ m$^3$/a is for urban and industrial use (Anon, 1986b).

Although the indirect reuse of treated wastewaters is well established in Southern Africa, especially in the inland areas, direct reuse, which is the planned and deliberate use of a treated wastewater, has only been used to a limited extent, e.g. Windhoek - Namibia. Growing water shortages, however, may well force direct reclamation before the turn of the century, especially in coastal centres where indirect use is generally not desirable (Odendaal, 1989).

As in the other centres around Southern Africa, Cape Town can no longer be assured of unlimited supplies of fresh water.

Against this background an investigatory pilot plant programme for the reclamation of treated wastewater was initiated in the Western Cape.

CONTRACT AGREEMENT

The agreement between the Water Research Commission (WRC) and the Cape Town City Council (CCC) stipulated that the WRC would make funds available on request to the CCC for the following:

* construction of the Cape Flats plant
* modifications as deemed necessary during the project
* surveillance of the reclaimed water quality

The CCC in turn would:

* provide the necessary personnel and facilities
* carry out the working programmes
* assume responsibility for the design and construction
* operate the plant
* be responsible for the financial administration
compile a comprehensive final report on the results and findings for submission to the WRC.

OBJECTIVES

The main objective was to develop a practical process configuration to consistently produce potable water from the Cape Flats wastewater treatment works effluent as a possible resource for augmentation of existing potable water supplies.

Various secondary objectives were pursued in order to achieve this objective, namely:

- the application and evaluation of techniques and operating procedures
- the integration feasibility of reclaimed water with available resources
- the development and execution of chemical, bacteriological and virological surveillance programmes.

PROCESS DEVELOPMENT

The wealth of information which had already been obtained from the Windhoek, Pretoria and Athlone water reclamation projects was used as the basis of design and process development at the Cape Flats plant.

The flexible design of the plant provided a number of process configuration options. After the feed water was characterised with respect to its organic, inorganic and microbiological constituents an initial combination of unit processes was selected.

Subsequent thorough optimisation of the plant resulted in the selection of the following sequential process configuration:

- feed water quality equalisation and buffering
- chemical flocculation using ferric sulphate and a polyelectrolyte
- primary sedimentation
- primary chlorination
- rapid gravity sand filtration
- ozonation
- two stage activated carbon treatment
- final chlorination
- final calcium hydroxide stabilisation
PLANT OPERATION

The plant was commissioned during May 1982 and operated until December 1986. During this period various process adjustments were made and the flocculants ferric chloride, ferric sulphate and aluminium sulphate were successfully optimised. Ferric sulphate was chosen and used predominantly during the project as it was locally available and produced a good quality reclaimed water.

Throughout the project many operational and process configuration changes were made, viz:

* The variability in quality of the feed water from the adjacent wastewater treatment plant resulted in an optimisation programme of the activated sludge process being carried out by the University of Cape Town (UCT) (Ekama and Marais, 1984).

* An equalisation pond was constructed as a buffer between the activated sludge works and the reclamation plant.

* Break point chlorination between the primary settling and sand filtration processes resulted in the production of undesirable trihalomethanes (THM). The chlorine dose at this point was subsequently reduced but the final chlorine dose after activated carbon treatment was increased to achieve disinfection.

* Due to mechanical and operational problems the original pressure sand filters were found unacceptable and replaced with rapid gravity type sand filters.

* Ozonation, as an intermediate disinfection stage, was introduced during the final year of operation.

* Introduced a dry calcium hydroxide feed in place of a slurry feed.

SURVEILLANCE OF THE QUALITY OF THE RECLAIMED WATER.

An intensive surveillance programme using external testing laboratories was undertaken during the final three months of the project to obtain independent views of the quality of the reclaimed water. These included the CCC, UCT and the National Institute for Water Research (NIWR) now the Division of Water Technology (Watertek) of the CSIR.

The overall findings of the respective laboratories showed that the reclaimed water quality was well within the generally accepted standards for potable water.

CONCLUSIONS

1 Water reclamation, by the production of a potable water from an activated sludge plant effluent is a viable source for the supplementation of potable water supplies but should only be used when all other economical aspects of water supplementation have been explored and implemented.

2 The operational, maintenance and surveillance programmes proved conclusively
that larger local authorities are capable of owning, maintaining and running a water reclamation plant which consistently produces a water of potable quality.

3 The total cost of producing reclaimed water at the Cape Flats reclamation plant was about 88 c/m³ which is much higher than the cost of about 20 c/m³ of producing fresh water in the Cape Town area (1986 costs). Approximately 33% of the total cost was associated with the activated carbon process. It is envisaged that ozonation prior to activated carbon treatment and on site carbon regeneration would significantly reduce the production cost of a full scale plant. The costs of fresh and reclaimed waters will tend to converge in future.

4 The wastewater treatment works supplying the feed water to the Cape Flats reclamation plant is a nutrient removal plant of the five stage Bardenpho type and the process configuration of the reclamation plant was specifically selected for this type of effluent. Pilot or prototype plant studies should be undertaken before full scale implementation of a water reclamation scheme.

5 It is essential that the wastewater treatment works supplying the feed water to the reclamation process is properly optimised, operated and controlled. This would ensure that the quality of the feed water to the reclamation process would be free from major fluctuations in quality and that the consistent supply of an acceptable feed water would always be available. During periods where the quality is unacceptable this feed water should bypass the reclamation process.

6 The inclusion of a feedwater quality equalisation and buffer pond is essential to prevent water of fluctuating quality from being supplied to the reclamation plant.

7 The provision of backup or standby mechanical equipment is essential to maintain the uninterrupted production of a potable water supply.

8 A comprehensive virological study of the reclaimed water was conducted during the surveillance period. All the samples examined during this time were clear and no viruses or coliphages were detected. By virological standards the reclaimed water is perfectly potable (Hodgkiss et al., 1989).

9 The chemical quality of the reclaimed water, during the intensive surveillance period, conformed to the recommended limits for drinking water (Kempster and Smith, 1985).

10 Bacteriological examination of the reclaimed water during the intensive surveillance period indicated that, except for the standard plate count, the quality of the reclaimed water was well within generally accepted limits for drinking water. However, the occasional high standard plate count does not necessarily constitute a health risk but it does reflect occasional inadequate final disinfection.

11 The trihalomethane (THM) results obtained during the intensive surveillance period showed that the quality of the reclaimed water was well within the USEPA criterium of 100 μg/l for drinking water. An increase in the THM values over the last three weeks of the surveillance period indicated that the activated carbon had
become saturated with respect to the adsorption of THM's.

12 Consistently low dissolved organic carbon (DOC) concentrations were obtained on the reclaimed water throughout the intensive surveillance period.

13 The ongoing surveillance programmes which will be used in a full scale application will have to be intensive and will require more detailed analyses than for fresh water plants. It is essential that automatic surveillance equipment is provided.

14 Aluminium sulphate, ferric chloride and ferric sulphate were all successful as flocculants. Ferric sulphate however was used predominantly. Polyelectrolytes aided the flocculation process when added in low dosages.

15 The combined use of ferric sulphate and chlorine together with the poorly buffered feed water produced a corrosive water with a depressed pH value. Calcium hydroxide was used to stabilise this water to a pH value of about 9. This however resulted in the precipitation of relatively small quantities of calcium carbonate in the reclaimed water. This precipitate did not affect the final disinfection process as final chlorination preceded final stabilisation.

16 The use of ozonation prior to activated carbon treatment was found to increase the life of the carbon by about 40%. This concurs with other research findings (Van Leeuwen, 1988).