May 2016
The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

BRIEF

DESALINATION, RECLAMATION AND WATER REUSE R&D

Water reclamation and reuse has been studied in the region since the 1950s, which has led to the first direct water reclamation plant being built in Windhoek. Ongoing research and development at Windhoek has led to this plant being internationally considered as an effective multi-barrier treatment system.

Early work was done by the CSIR in early 1960s (Windhoek requirements); Windhoek direct reuse treatment plant was commissioned Oct '68.

- CSIR Stander demo plant 4.5 Ml/d 1970 Pretoria (direct reuse, for research)

Soon after the WRC was established in 1971, it set out to look at furthering research on the technology

- Test facility at Daspoort, Pretoria (photo below)
- Used the knowledge gained from the tests to upgrade the technology
- Process design manual for water reclamation in 1978

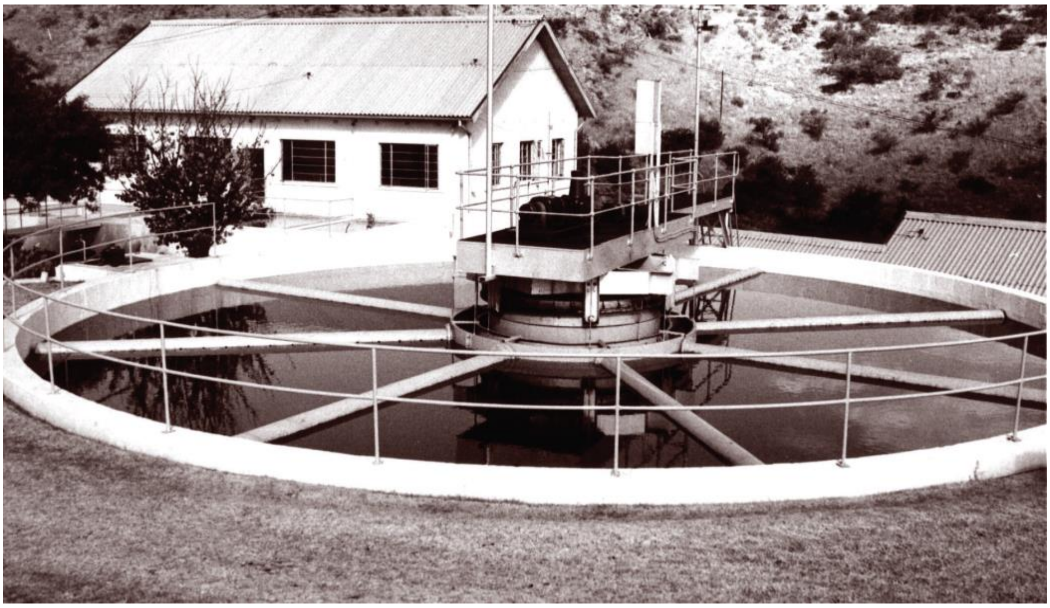


Figure 1: WRC / CSIR pilot test at Daspoort

In Southern Africa (and now also worldwide after the 2013 IWA Water Reuse Specialist Group conference in Windhoek), the City of Windhoek (CoW) and the original planners and researchers of the Windhoek water reclamation project, are considered pioneers in direct potable reuse (DPR). The first direct potable reuse plant was commissioned in 1968 and was the result of severe droughts in the regions, with no other viable water sources for the city. This has remained unchanged up to the present time. As the first, and until very recently the only, DPR plant in the world, considerable research and development had taken place in Windhoek to study health impacts, process efficiency and water management strategies. This was extended even further after the construction and commissioning of the New Goreangab Water Reclamation Plant in 2002. After more than 40 years of operation of direct potable reuse in Windhoek, no adverse health effects have been experienced.

Role of WRC in membrane research

The WRC has funded several projects on membrane research since its inception in 1971. However, most projects were funded after the establishment of a dedicated membrane programme in the early 90's. Sixty-six membrane projects were funded since 1993. Figure 2 represents the research that has been conducted as well as a number of ongoing projects. The WRC has funded almost 70 projects since the 1990s:

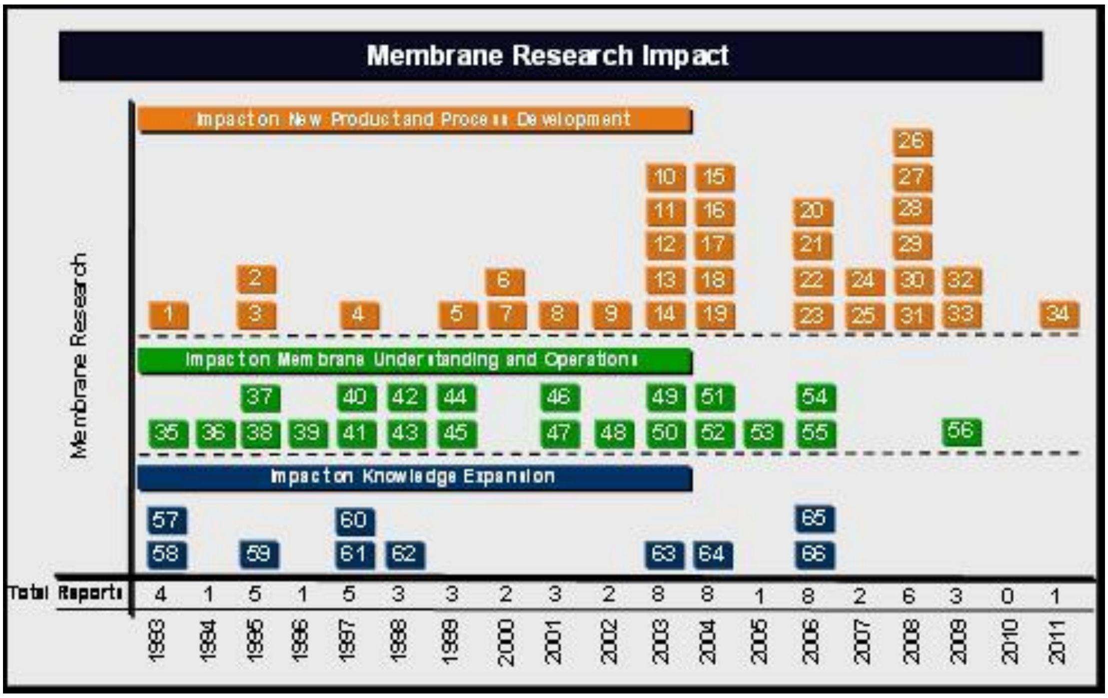


Figure 2: Membrane Research Impact Funded by the WRC

The research funded by the WRC has led to knowledge expansion. This knowledge and the applications thereof will further build the membrane industry in South Africa. An overview of the knowledge created is represented in Figure 3:

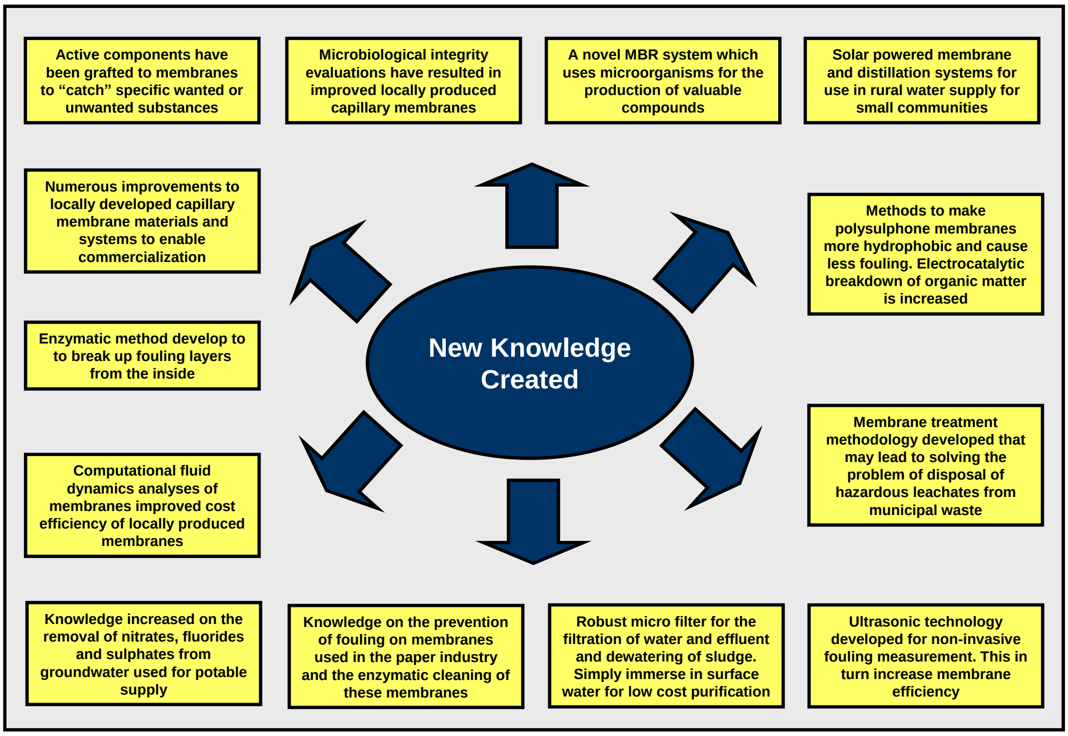


Figure 3: New Knowledge Created through WRC Funded Research Projects

The history of membrane research in South Africa

The earliest fundamental membrane research in South Africa started in 1953 on electrodialysis (ED) systems and their membranes at the Council for Scientific and Industrial Research (CSIR). This research laid the foundation for a better understanding of the thermodynamic and physical processes involved in ED. Parchment paper membranes were developed and piloted for the low-cost desalination of brackish gold-mine underground waters. Initial research on polymeric membranes, utilising WRC funding, started in 1973 at the Institute for Polymer Research (IPS), University of Stellenbosch, leading to the establishment of the first local membrane manufacturing company in 1979.

The IPS developed low cost tubular RO and UF systems in the 1980s. The tubular UF systems were later successfully combined with anaerobic digestion and commercialised as the "ADUF" process. From humble beginnings, these activities have grown to the current situation where R&D on membranes is actively pursued not only at a number of tertiary educational institutions, but also by private companies and water and power utilities.

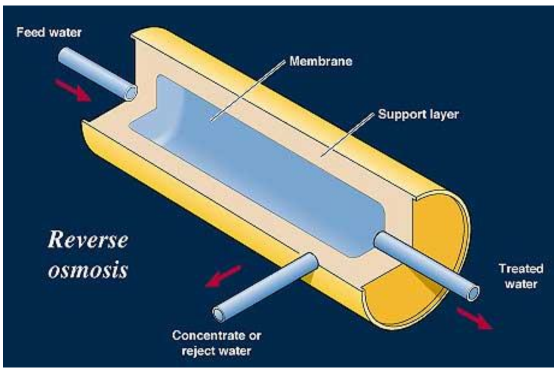
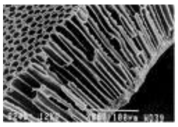
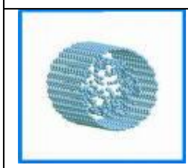
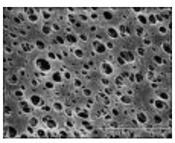
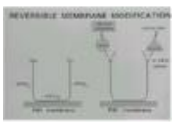


Figure 4: Reverse Osmosis Process

The table below gives an overview of some of the types of products that have been developed through research.

Table 1: Products Developed through WRC Funded Research

Some Products Developed through WRC Research		
	Type of Technology	**Description**
	**Ultrafiltration (UF) Membranes**	• Used for producing ultra pure water • Able to remove bacteria from water • Ideal for rural water applications for small communities
	**Reverse Osmosis (RO) Developments**	• Used to desalinate water sources • Increase available water resources
 	**Woven Fibre Microfiltration (MF) membranes**	• The tubular system consists of two layers of a woven polymer material, stitched together to form rows of parallel filter tubes, called a "curtain" • Liquid is fed from the inside and clear water permeates from the membrane (clarification process) • Can be used for sludge dewatering • A simplified, immersed, flat-sheet system was later developed for potable and industrial water treatment
	**Electroconducting Membranes**	• Membrane systems that use positive and negatively charged membranes to remove particles from the stream. • Some of the systems are able to produce sodium hypochlorite or ozone as by-products.
	**Supported Liquid Membranes**	• Shows the potential to extract metals such as nickel from liquid streams.
	**Membrane Bioreactors (MBRs)**	• Most of the studies are using the outer-skinless UF membrane as reactor (fungi are used in bioremediation of waste water). Flat-sheet woven microfilter units have lately showed great promise as inexpensive, robust, immersed MBRs.
	**Membrane Fouling Studies**	• Research on membrane fouling centres around three aspects: electromagnetic defouling; enzymatic and chemical defouling; as well as surface modification.
	**Affinity Separation**	• A process that involves extracting “wanted” elements from the stream through chemical reaction. It is being developed as an EDC detector.
	Nanostructured Membranes	• Nanotechnology can aid tailoring of membrane thickness, pore size

		distribution, permeability, and surface chemistry. Membrane design via templating chemistry allows entirely new and more effective membrane architectures to be engineered and developed. A new, nano-membrane has already been developed at UCLA which claims to provide RO quality water at much lower pressures.

Some of the major challenges facing research institutions in South Africa are how to 1) protect their intellectual property and 2) commercialise research. The figure below shows how the research process can eventually lead to benefits through project commercialisation. Additional funding for technology commercialisation and business skills development for researchers could significantly increase the successful commercialisation of research projects.

Some examples of how WRC research has led to commercial implementation in different situations are represented in Figure 5. Grahamtek was one of the biggest spin-offs of this investment. It was bought out by PUB Singapore and now operate under the name of NuWater. NuWater is nregaded as one of the leading technology supplier of desalination plants in the world today.

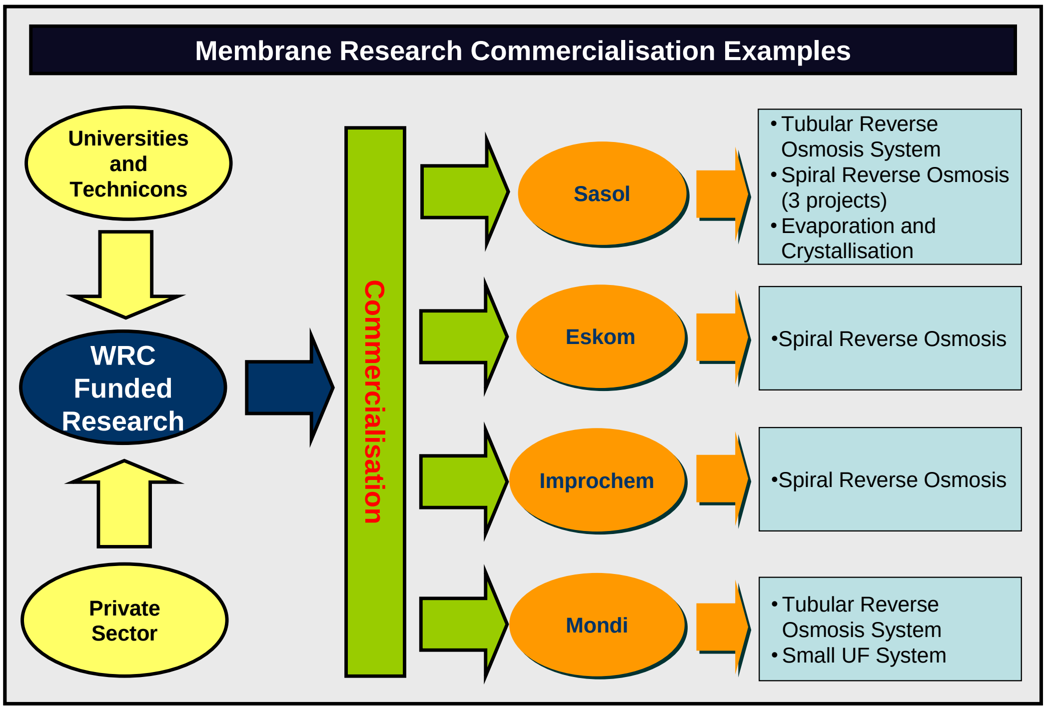


Figure 5: Membrane Commercialisation Examples

During this period of R&D development, the South African Government strategy was on building of bulk infrastructure such as dams and transfer schemes as a means to deal with droughts and water scarcity. Energy was a constraint, even then, as the membranes were not that efficient. Over the years this has changed and energy effiency has improved, resulted in greater interest and uptake of desalination and reclamation option.

With foresight in 2006, the Water Research Commission and the Department of Water Affairs and Forestry jointly funded a study aimed at assessing the applicability and economic considerations of various options to desalinate water from the sea, brackish boreholes and other sources to produce drinking water in order to meet the rising demands of water supply. A guideline document (A desalination guide for South African municipal engineers - Research Report No.TT 266/06) - was produced from this study. The guideline provides guidance on desalination technologies that can currently be commercially implemented in South Africa to treat different saline water to drinking water standards; typical pre-treatment requirements, process selection and costing; pre- and post-treatment requirements; management of residuals; environmental considerations and operation and maintenance aspects.

During the 2009/10 drought in South Africa, a number of small scale desalination plants were commissioned as an emergency water supply measure. In 2012, the Water Research Commission funded a study that was aimed at investigating the sustainability of desalination (Cost and operational aspects of seawater desalination plants – Research Report No.TT 636/15; 637/15 and 638/15) as a water supply measure by looking at the planning and operational aspects of these plants and compile best practices and lessons thereof.

Other projects that have been recently funded include:

- Solar energy for desalination (ongoing)– K5/2467
- Brine management (ongoing) – K5/2576
- A comparative life cycle assessment (LCA) for the provision of potable water from alternative sources (seawater, wastewater and mining water) in South Africa – K5/1122

A national community of practice on desalination has already been established, where guidance and support is provided to municipalities on planning and the implementation of large scale water supply.

Future research areas include;

- Investigation of seawater desalination by using hybrid renewable energy technologies in South Africa
- Framing desalination within the water-energy-climate nexus – understanding the water and energy decisions within the context of desalination is important as it has significant climate impacts.
- Economic and technical assessment of current and emerging desalination technologies

REPORTS AND GUIDELINES (RECENT)

- A desalination guide for South African municipal engineers - Research Report No.TT 266/06
- Cost and operational aspects of seawater desalination plants – Research Report No.TT 636/15; 637/15 and 638/15
- A comparative life cycle assessment (LCA) for the provision of potable water from alternative sources (seawater, wastewater and mining water) in South Africa – K5/1122