DEVELOPING ALTERNATIVE WATER SOURCES – WE “SEA” POSSIBILITIES

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ABSTRACT

Conventional water resource development options in South Africa are proving to be increasingly more difficult to implement. Feasible sites for new dams are becoming scarce. Variability in runoff, the impacts of climate change, and the provision for environmental water requirements all impact on the potential sustainable yields from surface water schemes. The National Department of Water and Sanitation, and various Water Service Providers are investigating alternative sources of supply, one of which is sea water desalination.

Umgeni Water (UW) has recently undertaken a Detailed Feasibility Study (DFS) of two potential 150 Ml/day Reverse Osmosis (RO) desalination plants near Durban. Of 11 sites identified initially, two were found to be the most suitable for a feasibility study, namely one at Tongaat (30km north of Durban) and another at the Lovu River Estuary (30km south of Durban). A 12-month sea water quality monitoring program was undertaken to determine the water quality factors that would influence the design of the pre-treatment system. Brine dispersion modelling was used to assess the dispersion characteristics of the resulting brine that would be discharged to sea.

The integration of the desalinated water into the existing potable water supply system was also investigated, both from a phasing and from a water quality perspective. RO desalination of sea water appears feasible at both sites. The estimated capital cost is in the order of R4 billion per 150 Ml/day plant. A parallel Environmental Impact Assessment (EIA) is currently in progress.

The Reconciliation Strategy Study for the Kwazulu-Natal Metropolitan Coastal Areas indicates that even with further augmentation of the Mgeni System (including the recent implementation of Spring Grove Dam shown in Figure 1) by an additional 137 Ml/day (50 million m³/a), the supply of water in future will not be of an adequate assurance of supply. Phase 1 of the proposed Mkomazi Water Project is planned to secure an additional 326 Ml/d (119 million m³/a). This R17 billion project involves the potential development of Smithfield Dam located in the central reaches of the Mkomazi River, with a storage capacity of 137 million m³ (137 000 Ml).

Hazelmere Dam will be raised in the near future and feasibility studies of other alternatives that could be implemented more rapidly than the Mkomazi Water Project are being undertaken as alternatives to the Lovu and Tongaat desalination plants, for which EIAs are currently being undertaken.

This paper describes the study undertaken, its conclusions, recommendations and key lessons learned.
1. INTRODUCTION

The water requirements of the Kwazulu-Natal Coastal Metropolitan areas in the vicinity of Durban are growing rapidly. Approximately 92% (1072 Ml/d) of the water provided by Umgeni Water (UW) to the six water services authorities it supplies is sourced from the Mgeni System. This system consists of an extensive network of pipelines, aqueducts, water treatment works and reservoirs, supplied from the Midmar, Albert Falls, Nagle and Inanda Dams in the Mgeni System, as well as from Hazelmere Dam on the Mdloti River. The Mooi-Mgeni transfer scheme from Smithfield Dam supplements the supply of water in the upper Mgeni River (Midmar Dam).

Conventional water resource development options, particularly surface water schemes, are becoming less viable. The most feasible sites for new dams or abstraction works have, in some areas, already been developed. This coupled with the impacts of climate change on rainfall and runoff, as well the need to provide for downstream environmental water requirements, adversely impacts on the sustainable yield that can be developed from surface water schemes. Alternative sources of bulk water supply are therefore being investigated by the National Department of Water and Sanitation, and Water Service Providers. One such alternative is that of sea water desalination.

UW recognizes the possibility of implementing desalination at a large scale as an alternative to the Mkomozi Water Project and/or Lower Mkomozi Water Project, and as a scheme which could be implemented fairly quickly, with opportunity for phasing of its implementation.

A desktop study was undertaken in 2011 to determine appropriate sites at which large scale desalination plants could be positioned along the KwaZulu-Natal Coastline near Durban. The study initially identified 11 possible sites consolidated to two preferred sites, one on the North Coast (on the Mdloti River 30km north of Durban) and one on the South Coast (at the Lovu Estuary 30km South of Durban). (see Figure 2).

Towards the end of 2012, UW appointed Aurecon to undertake a due diligence exercise and full Detailed Feasibility Study (DFS) of the two potential desalination plants.

2. DUE DILIGENCE PHASE

As a precursor to the DFS, a Due Diligence Assessment was undertaken for each site to confirm its suitability for a 150Ml/d desalination plant. Both sites were inspected and initial assessments undertaken in respect of sea water quality, geotechnical conditions, required infrastructure, pipeline alignments and pump station locations, marine biology, botanical considerations, and estuarine impacts.
The key outcome of the Due Diligence Assessment was a recommendation that, due to the anticipated adverse impacts on the Mdloti River estuary, an alternative site immediately north at Tongaat was recommended as a preferred alternative. A DFS and preliminary design were, thereafter, undertaken at both the Lovu and Tongaat sites.

3. DESALINATION TECHNOLOGIES CONSIDERED

Distillation technologies include thermal and membrane processes. Thermal distillation takes the form of multi-stage flash distillation, multi-effect distillation, mechanical vapour compression distillation and thermo-vapour compression distillation. Each of these were considered for possible implementation, taking cognisance of their energy requirements, suitability for implementation at the scale of 150Ml/d, existing track records, and efficiency of production. Membrane technologies included electrodialysis and RO. These were similarly considered and evaluated in terms of their track records, energy requirements, intended applications, and the proposed scale of implementation. RO was found to be the most suitable treatment process for this application.

RO is currently the most widely implemented desalination process globally with successful commercialization having taken place from as early as 1970. The technology has been applied in over 90% of municipal desalination plants built world-wide, over the past two decades (Voutchkov, [in press]). Figure 3 shows the typical components of an RO system.

RO is a process which uses pressure to force pre-treated saline water (such as sea water) through fine membranes, which enables the salt to be removed. This produces fresh water as a product, and salty brine as a bi-product. The brine is typically returned to sea under controlled conditions. The RO process has high energy demands, but does offer very viable means of utilising surplus energy from the process, to reduce the energy demand from the national grid.

RO removes dissolved salts from saline water by a process similar to filtration, and as such the membranes are susceptible to fouling by colloids, organics, iron and manganese. Consequently extensive pre-treatment is required, to reduce membrane fouling and maximise membrane life. Typically sea water RO plants operate at a recovery rate of up to 50% (ie the potable product water amounts to about half of the volume of sea intake sea water). Although pressurizing the feed water requires substantial energy, RO has a lower energy requirement (4-5 kWh per m$^3$) than distillation processes (Blinda, 2010).

Figure 3 Typical Components of a Reverse Osmosis System
To overcome the osmotic pressure of sea water requires pumping pressures in excess of 70bar. Permeate is collected from the membranes and the concentrated brine stream is produced at a high surplus pressure, which enables energy recovery measures to be implemented.

**Figure 4** shows the footprint of a 350ML/d desalination plant in Israel (Ashkelon). RO plants are modular in nature and are well suited to large scale implementation. The largest currently in operation is the Sorek RO plant, also in Israel, which was completed in 2013 and when operated at full capacity, will be capable of producing 627,000m$^3$/day (627 ML/d). Having evaluated the advantages and disadvantages of the available technologies, RO was found to be the most suitable for the scale of implementation intended by UW, i.e. 150 ML/day.

### 4. SEA WATER QUALITY MONITORING

Source water quality has important implications for the desalination process. The most common operational issue encountered in sea water RO plants is the formation of deposits (fouling) on the surface of the pre-treatment filters and on the RO membranes themselves.

The quality of the source water also has important implications for product water quality and, in the case of production for potable water, human health issues need to be considered. Therefore an understanding of the quality of the source sea water is critical when assessing the feasibility of desalination plants. Site specific data on sea water quality off the coast of KZN prior to this study was largely lacking.

In order to learn more about the coastal conditions and environment, a 12-month sea water quality sampling and testing program was undertaken and monitoring buoys were deployed at the two proposed desalination plant intake locations (see **Figure 5**). Sampling stations were located at three depths (10m, 15m and 20m), and sampling commenced in June, 2012 with continuous measurement of salinity, turbidity, temperature, chlorophyll and water currents. Discreet sampling of other determinants was also undertaken on a weekly basis over the same period.

The broad “classes” of water quality parameters assessed included nutrients, metals, anions/cations, hydrocarbons and conventional determinants, while biological classes include bacteria and algae. Following the sea water quality monitoring it was confirmed that the quality of water would be suitable for desalination at both sites, and that the plant designs could be similar. A seasonal occurrence of micro algae was found to be of particular concern in terms of potential membrane fouling. A pre-treatment pilot plant is currently being implemented by UW to assess the effectiveness of various pre-treatment filters in the removal of the algae upstream of the RO membranes.
5. MARINE MODELLING

Both desalination plants require a marine intake to deliver sea water to the RO plant and a marine outfall to return the concentrated brine to sea. The key tasks undertaken to support the design of this infrastructure were hydrographic and geophysical surveys (bathymetry), near field dilution modelling (initial dispersion) and the plume dispersion (far-field) modelling.

Marine surveys extended across a grid of 2km$^2$, with grid lines approximately 50m apart, and depth sampling every 5m along each gridline to determine the bathymetry (bed profile – see Figure 6), depth of sand, and reef exposure.

Near-field dilution and far-field dispersion modelling (undertaken by WSP Coastal Engineering) was critical for determining the extent and range over which the saline (brine) plume would be dispersed. This information will also be used in an assessment of the likely impacts on the marine environment, including the impacts on benthic species, as well as to provide support in the application for a marine waste discharge licence.

The near-field modelling for a 60m long diffuser with fifteen discharge ports indicated that on average, dilutions within the water column of between 18 and 28 times were achieved at distances of between 6 and 10m from the diffuser. The far-field dispersion results (see example output in Figure 7) indicated that on average, salinities primarily remained below 0.5 ppt above ambient at 30m from the diffusers, and rarely persisted for more than a day (in total) during a simulated season. Concentrations were found to rapidly decrease with distance from the discharge location.

6. THE REVERSE OSMOSIS SYSTEM

The results of the 12-month sea water quality monitoring concluded that, due to minor variations in water quality characteristics between Tongaat and Lovu, the same RO system could be applicable at both sites. A pre-treatment system consisting of either granular media filters, or membrane filters, or both, would enable the removal of the majority of suspended solids so as to protect the RO membranes from accelerated fouling by contaminants.
Single pass or two pass RO systems (or variations thereof) are possible. In a single pass system, the filtered sea water passes through one set of RO membranes (see Figure 8).

A two pass system has advantages in terms of the quality of the product water. However, this needs consideration in the context of the proposed use of the product water, and of the quality of water from other sources with which it may be blended.

Single pass systems have two primary product water quality considerations, namely elevated bromide and boron concentrations.

If water produced by a single pass RO system (with elevated bromides) is blended with other water disinfected with chloramines, then there is a risk of destruction of the chlorine residual in the chloraminated water. Boron concentrations are only of concern where desalinated sea water is to be used for irrigation. Although not the intended use by UW, this can have implications where water is ultimately reused for watering of golf courses, school fields and public open spaces for example, and grass die-off or stunted growth could eventually result.

As water from desalination plants is characteristically low in mineral content, hardness, alkalinity and pH, it must be conditioned (post-treated) prior to final distribution and use. Post-treatment of fresh water produced by desalination has two key components. These are mineral addition (lime and carbon dioxide or lime contactor) in order to safeguard the integrity of the water distribution system, and disinfection to protect public health (chlorination or chloramination as discussed above).

The product waste streams from a desalination plant include concentrate (brine) as well as small concentrations of spent backwash water from the pre-treatment system, spent membrane cleaning solution, and flush water. Energy used for sea water desalination contributes 50 to 70% of the total plant annual Operation and Maintenance (O&M) costs, and 25 to 35% of the total costs of fresh water production. Consequently reuse of energy is very beneficial and cost effective and is achieved through the use of Energy Recovery Devices (ERDs).
7. MARINE INFRASTRUCTURE

The geology at the two respective sites has influenced the preliminary design of the marine intake and outfall infrastructure at Lovu and Tongaat. At Lovu, the deeper sand sediments have resulted in a recommended conventional pipe laying approach for both the intake and the outfall. The resulting configurations at Lovu are:

- 2 x 1,600 mm (OD) HDPE intake pipelines (each 1220 m long);
- 1 x open intake structure
- 1 x 1,600 mm (OD) HDPE outfall pipeline (630 m long); and
- 1 x 1,600 mm (OD) HDPE tapered diffuser (60m long).

At Tongaat the more rocky geology lends itself to a combination of micro tunnelling (see Figure 9) and pipelines (beyond the surf zone), resulting in:

- 1 x intake tunnel launch pit at the plant site;
- 1 x 2,000 mm (ID) pipe-jacked intake tunnel (680 m long);
- 1 x 1,800 mm (OD) HDPE intake pipe on the sea bed (220 m long);
- 1 x open intake structure;
- 1 x outfall tunnel launch pit at the plant site;
- 1 x 2,000 mm (ID) pipe-jacked outfall tunnel (520 m long);
- 1 x 1,600mm (OD) HDPE tapered diffuser (60m long) on the sea bed.

The use of two intake pipelines at Lovu is a result of a design balance between pipe diameter, availability, and constructability. Both sites will make use of an open water offshore intake (see Figure 10) with primary (course) screens having bar spacings at about 150mm centres. These types of intakes are more suited to larger scale desalination plants, such as the two that are proposed. Alternative intake arrangements were considered, such as offshore sub-surface intakes and onshore beach wells. However, the scale of the intake volumes required at both sites is such that these alternatives prove unfavourable from a footprint size and environmental impact perspective.

8. SEA WATER DELIVERY AND BRINE RETURN FLOW PIPELINES

The marine infrastructure described previously serves to:

- deliver the sea water to a pump station on the shore from where it is pumped to the desalination plant;
- return the brine from the pump station to sea.

Therefore between the onshore pump station and the desalination plant, a land-based rising main is required to convey the sea water to the plant. Similarly a brine return pipeline is required to connect the desalination plant to the offshore brine outfall.
The Lovu Scheme – Figure 11 shows the layout of the proposed scheme and the three options considered for the terrestrial pipeline alignments between the sea water intake pump station (at the beach) and the desalination plant site (3km away), namely:

- **Option A (**) would comprise two parallel 1800 mm HDPE pipelines (one sea water, one brine) laid in the Northern floodplain of the Lovu River Estuary by conventional pipe trenching, with a specially constructed pipe bridge for the river crossing.

- **Option B (**) involves two 2000 mm diameter parallel 1100 m long micro tunnels (one sea water, one brine) to the Southern bank of the Lovu River. From there two 1800 mm diameter HDPE pipelines would be laid by conventional pipe trenching to the desalination plant.

- **Option C (**) comprises two 2000 mm diameter parallel 650 m long micro tunnels (one sea water, one brine) to the Northern bank of the Lovu River Estuary, from where two parallel 1800 mm HDPE pipelines would be conventionally laid, crossing the river by means of a specially constructed pipe bridge.

Having considered the geotechnical, engineering, environmental and cost implications, Option A was found to be preferable for the land-based delivery, and brine return flow pipelines for the Lovu scheme.
At **Tongaat** (see Figure 12), the intake and outfall shaft would be located within the desalination plant site and as such the land-based sea intake pipeline and brine return pipeline connecting the shaft to the adjacent desalination plant would be very short.

![Figure 12  Tongaat Conveyance Infrastructure](image)

### 9. INTEGRATION OF POTABLE WATER INTO EXISTING SYSTEMS

The Lovu Desalination Plant would supply water to UW’s South Coast Regional Bulk Supply System and would also supply some of the areas served by the SCA Pipeline (southern areas of Durban) that are currently supplied by the Wiggins Water Treatment Plant. The desalination plant would be constructed in two 75ML/d phases with the timing of the second phase dependent on future water demand growth.

At Tongaat, water would initially be supplied to eThekweni Municipality’s Northern Aqueduct via Waterloo Reservoir from where the water would be pumped into the Northern Aqueduct (northern areas of Durban). As the demand of UW’s North Coast Supply System increases and exceeds the supply from the raised Hazelmere Dam and from the Lower Thukela Bulk Water Supply Scheme, the supply to the North Coast from the desalination plant would be increased by delivering water to the Avondale Reservoir (Ballito). The same two phased approach to the RO components would be adopted as at Lovu.

### 10. BULK POWER SUPPLY

Each desalination plant would require between 24 and 32 MW of power. The power supply to the Lovu desalination plant and its sea water pump station would be from the nearest 132kV point of supply, which is the Kingsburg Major Substation in Ilovo, about 2.5km from the proposed desalination plant site. The supply to the sea water pump station at the beach would be via an 11kV overhead line from the desalination plant site.

At Tongaat the nearest 132kV point of supply for the desalination plant and the sea water pump station (also located at the desalination site) is the La Mercy Major Substation on the western side of King Shaka...
International Airport. Timeous communication with eThekwini Electricity will be important as the substation is located on the western side of the airport and obtaining way leaves and a servitude for the 132kV transmission line to the proposed site could be problematic.

11. PROCUREMENT OPTIONS

A range of procurement options have been considered, from Design-Bid-Build (DBB) procurement, the form most familiar to UW, to a Design-Build-Operate-Train-Transfer (DBOTT) procurement option. The latter would involve UW entering into a single contract with a private operator to design, build and operate the plant, whilst also providing training and support to UW staff over the duration of the contract. The private company would assume all responsibilities and risks for implementation and operations. The asset would be transferred to UW at the end of the contract period, typically 25 years in length. A DBB desalination contract would take just over 7 years to be implemented whilst a DBOTT desalination contract could be implemented within 5 years.

12. RISK ANALYSIS

Potential risks that could impact on the proposed desalination plants were identified. The impacts, consequences and probability of each were identified, as well as the control measures that would be possible to mitigate the impacts. The scale used for each of the variables and indicators used is shown below:

<table>
<thead>
<tr>
<th>Consequences</th>
<th>Score</th>
<th>Probability</th>
<th>Score</th>
<th>Control Strength</th>
<th>Score</th>
<th>Residual Risk</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catastrophic</td>
<td>5</td>
<td>Almost certain</td>
<td>5</td>
<td>Excellent</td>
<td>95%</td>
<td>Very High</td>
<td>20</td>
</tr>
<tr>
<td>Major</td>
<td>4</td>
<td>Likely</td>
<td>4</td>
<td>Very Good</td>
<td>90%</td>
<td>High</td>
<td>15</td>
</tr>
<tr>
<td>Moderate</td>
<td>3</td>
<td>Moderate</td>
<td>3</td>
<td>Good</td>
<td>70%</td>
<td>Medium</td>
<td>10</td>
</tr>
<tr>
<td>Minor</td>
<td>2</td>
<td>Unlikely</td>
<td>2</td>
<td>Satisfactory</td>
<td>50%</td>
<td>Low</td>
<td>6</td>
</tr>
<tr>
<td>Negligible</td>
<td>1</td>
<td>Rare</td>
<td>1</td>
<td>Weak</td>
<td>30%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>None</td>
<td>-</td>
<td>N/A</td>
<td>N/A</td>
<td>Unsatisfactory</td>
<td>10%</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Seventy-four risks were identified, scored and ranked and only the following four were considered to be potential “fatal flaws”:

- The possibility that the eventual marine geotechnical conditions at Tongaat could render tunnelling a non-feasible option.
- The risk at Lovu of incorrect installation of marine pipelines due to difficulties in crossing the surf zone.
- The possibility that the bulk power supply to the desalination plant would not be implemented on time.
- The risk that the EIA record of decision is not in favour of desalination.

However, none of the above are considered likely, and mitigation measures and controls are possible for each of them.
13. FINANCIAL ASSESSMENT

Preliminary estimates of the capital and operating costs of the Lovu and Tongaat Desalination Plants are given in the table below.

<table>
<thead>
<tr>
<th>Cost Component</th>
<th>Lovu Desalination Plant</th>
<th>Tongaat Desalination Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction Cost (R billion)</td>
<td>3.7</td>
<td>3.9</td>
</tr>
<tr>
<td>Total Cost (R billion) (Note 1)</td>
<td>4.1</td>
<td>4.3</td>
</tr>
<tr>
<td>Capital Charge (R/m3) (Note 2)</td>
<td>6.4</td>
<td>6.69</td>
</tr>
<tr>
<td>Operating Cost (R/m3) (Note 3)</td>
<td>5.75</td>
<td>5.27</td>
</tr>
<tr>
<td>Operating Cost (R/m3) (Note 4)</td>
<td>8.23</td>
<td>7.42</td>
</tr>
</tbody>
</table>

Note 1: Total cost includes land acquisition, professional fees, project management and administration, further geotechnical investigations, etc.

Note 2: An interest rate of 9% and inflation rate of 6%. A loan redemption period post construction of 23 years (including construction 25 years). Only construction costs are included in the calculation.

Note 3: Assumes inflation related increase in electricity. The figure in the table represents the real cost in 2027 when the full capacity of 150 Ml/d is implemented.

Note 4: Assumes that the electricity tariff will increase by approximately 45% in real terms by 2017 from the 2014 base, and thereafter by 2% in real terms for the balance of the loan redemption period. The figure in the table represents the real cost in 2027 when the full capacity of 150 Ml/d is implemented.

Whilst the Lovu Desalination Plant has a higher offshore cost component, the Tongaat Plant has slightly higher overall capital costs, primarily due to the lengthy potable water infrastructure required to integrate the desalinated water into the existing potable water supply system. The Lovu Desalination Plant has a higher operating cost due to the higher energy cost required to pump the desalinated water into the existing potable water supply systems.

14. CONCLUSIONS AND RECOMMENDATIONS

General Conclusions and Recommendations

Water Quality Monitoring
Sporadic water quality analysis is recommended to take place 30 days before initiation of detailed design, at mid-construction period, and again 30 days before the commencement of plant commissioning.

Sea Water Intake and Brine Discharge
A circular offshore open intake structure of 12 metres diameter is recommended. Vertical turbine centrifugal pumps in a dry well are recommended for the sea water intake pump stations because of the lower operation and maintenance costs.

The brine discharge system should be designed to enable full discharge of the sea water intake flow, in the event of a shut-down being required at the desalination plant. Pipe material for the sea water rising main and the brine return flow pipelines should be the same so as to optimise the cost of manufacture and supply.

Pre-treatment
A pilot filter plant should be implemented to determine the most appropriate pre-treatment technology especially taking consideration of elevated algal concentrations. This is currently being implemented. A two-stage pre-treatment system is recommended due to the seasonal elevations in the concentration of algae in the source waters.

Reverse Osmosis System
A single pass RO system for both potential desalination plants is recommended, subject to a Water Quality Integration Study being undertaken to assess the impact of desalinated water produced by a single pass RO system on the other water sources with which it may be blended.
Post-treatment / Disinfection
Lime and carbon dioxide for post-treatment of the desalinated water is recommended. However, consideration should also be given to the use of limestone (calcite) contactors as an alternative because of their potential cost and performance benefits.

Waste handling
The recommended plant liquid waste handling involves equalization, neutralization and blending of all streams prior to discharge via the brine outfall and does not involve the generation of significant volumes of solid waste.

Contractual and Procurement
The method of procurement should minimise the design risk for plant and the risks during construction and commissioning. A Design-Build-Operate-Train-Transfer Procurement option would offer limited risk, would have a relatively short implementation duration (~5 years) and would include a capacity building program from which UW would benefit.

Phasing of Implementation
It is recommended that the infrastructure serving the desalination plant be sized to meet the ultimate demand of 150 ML/day. The same applies to the sea water pump station and the treated water pump stations. The RO components should be phased in two 75 ML/day increments.

Lovu-specific Conclusions and Recommendations
The recommended configuration for the Lovu scheme is one involving an open offshore intake structure with twin HDPE intake pipelines each of 1,600mm diameter (OD), and 1220m long. These would be trenched from the sea water pump station (adjacent to the beach), through the surf zone, and then laid on the sea bed to the intake structure. Concrete weight collars would anchor the pipelines to the sea bed. A single 1,600mm diameter (OD) HDPE outfall pipeline of 630m length equipped with a 60m long tapered diffuser would also be anchored on the sea bed for discharging the brine return flow to sea.

Two parallel 1800 mm HDPE pipelines (one for sea water, one for brine) would connect the sea water pump station to the desalination plant, located approximately 3km up the Lovu River Estuary. These pipes would be laid in the Northern floodplain of the estuary by conventional pipe trenching, with a specially constructed pipe bridge for crossing the Lovu River.

Tongaat-specific Conclusions and Recommendations
The recommended configuration for the Tongaat scheme would involve a partially tunnelled and conventional pipeline solution. The geology is such that tunnelling directly from the desalination plant (located within 300m of the beach), through the surf zone could be a viable solution. This would involve the construction of a tunnel launch pit at the desalination plant site, from where two tunnels would be excavated by means of a micro-tunnel boring machine. One tunnel would serve as the intake and would be of 2,000mm diameter (ID), 680m long. This would then link to the sea bed by means of a vertical riser, from where a conventional 1,800mm diameter (OD) HDPE intake pipe of 220m in length would lead to the open intake structure.

The second tunnel (for brine discharge) would extend for a distance of 520m from where it would link to the sea bed by means of a vertical riser. From there it would connect to a 1,600mm diameter (OD) HDPE tapered diffuser (60m long) on the sea bed.

15. REFERENCES

Umgeni Water East Coast Desalination Plants Detailed Feasibility Study. Reports 601.3.2/R01-R08/2015.